Chapter 10
Central Sand Plains Ecological Landscape

Where to Find the Publication

The Wisconsin DNR's *Ecological Landscapes of Wisconsin* publication is available online, in CD format, and in limited quantities as a hard copy. Individual chapters are available for download in PDF format through the DNR website (http://dnr.wi.gov/, keyword "landscapes"). The introductory chapters (Part 1) and supporting materials (Part 3) should be downloaded along with individual ecological landscape chapters to aid in understanding and using the ecological landscape chapters. In addition to containing the full chapter of each ecological landscape, the website highlights key information such as the ecological landscape at a glance, Species of Greatest Conservation Need, natural community management opportunities, general management opportunities, and ecological landscape and Landtype Association maps (Appendix K of each ecological landscape chapter). These web pages are meant to be dynamic and were designed to work in close association with materials from the Wisconsin Wildlife Action Plan as well as information on Wisconsin's natural communities from the Wisconsin Natural Heritage Inventory Program.

If you have a need for a CD or paper copy of this book, you may request one from Dreux Watermolen, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.

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Cover Photos

Top left: *Wisconsin's Central Sand Plains Ecological Landscape is a global stronghold for the U.S. Endangered Karner blue butterfly. Here a male Karner blue is shown nectaring on sunflower. Photo Thomas Meyer, Wisconsin DNR.*

Bottom left: *Cambrian sandstone bedrock rises abruptly from the level bed of extinct Glacial Lake Wisconsin. Mill Bluff State Park. Photo Wisconsin DNR staff.*

Top right: *Pine Barrens community with scattered small jack pines and a rich sand prairie understory. Bauer-Brockway Barrens State Natural Area, Jackson County. Photo by Eric Epstein, Wisconsin DNR.*

Center right: *This extensive open peatland complex of poor fen and northern sedge meadow is on the Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.*

Bottom right: *An attempt is being made to restore a breeding population of the globally imperiled Whooping Crane to remote portions of the Central Sand Plains. Photo courtesy of U.S. Fish and Wildlife Service.*

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Size

3,420 square miles (2,188,861 acres), representing 6.1% of the land area of the state of Wisconsin.

Climate

Typical of southern Wisconsin, the mean annual temperature is 43.8°F, mean annual precipitation is 32.8 inches, and mean annual snowfall is 45.0 inches. However, the mean growing season (135 days) is almost 19 days less than other southern Wisconsin ecological landscapes. Summer temperatures can drop below freezing at night in low-lying areas, restricting the distribution of some native plants. The short growing season and summer frosts limit agriculture, especially west of the Wisconsin River where commercially grown cranberries are an important crop. East of the Wisconsin River, the growing season is somewhat longer (by approximately 11 days), with fewer nights of potential summer frost. In this area, agriculture is focused primarily on cool season crops such as potatoes, vegetables, and early maturing corn. Center pivot irrigation is widely used to water crops in this region of sandy soils. Grazing is a common land use practice in some areas.

Bedrock

The Central Sand Plains Ecological Landscape is underlain by Late Cambrian sandstone that contains strata of dolomite and shale. Most exposures are of Cambrian sandstones. Precambrian igneous (granite) and metamorphic (gneiss) rocks lie beneath the sandstone and are exposed in a few places (e.g., in rapids on the Black River and East Fork of the Black River).

Geology and Landforms

An extensive, nearly level expanse of lacustrine and outwash sand that originated from a huge glacial lake characterizes much of the Central Sand Plains. Sand was deposited in Glacial Lake Wisconsin by outwash derived from melting glaciers to the north. Exposures of eroded sandstone bedrock remnants as buttes, mounds, and pinnacles are unique to this ecological landscape. Sandstone is also exposed as cliffs along the Black and Wisconsin rivers and several of their tributaries.

Soils

Most soils formed from deep sand deposits of glacial lacustrine or outwash origin or in materials eroded from sandstone hillslopes and sometimes with a surface of wind-deposited (aeolian) sand. These soils are excessively drained, with very rapid permeability, very low available water capacity, and low nutrient status. In lower-lying terrain where silty lacustrine material impedes drainage, the water table is very close to the surface. Such areas are extensive in the western part of the ecological landscape where soils may be poorly drained with surfaces of peat, muck, or mucky peat. Thickness of peat deposits ranges from a few inches to more than 15 feet.

Hydrology

The hydrology of the Central Sand Plains is characterized by large areas of wetlands and a number of generally low-gradient streams that range from small coldwater streams to large warmwater rivers. Major rivers include the Wisconsin, Black, East Fork of the Black, Yellow, and Lemonweir. A number of headwaters streams originate in the extensive peatlands west of the Wisconsin River. Natural lakes are rare and are limited to riverine floodplains and a few scattered ponds within the bed of extinct Glacial Lake Wisconsin. The hydrology of this ecological landscape has been greatly disrupted by past drainage, channelization, impoundment construction, and groundwater withdrawal.

Current Land Cover

The eastern portion of the Central Sand Plains is a mosaic of cropland, managed grasslands and scattered woodlots of pine, oak, and aspen. Many of the historic wetlands in the east were drained early in the 1900s and are now used for agricultural purposes. The western portion of this ecological landscape is mostly forest or wetland. Oak, pine, and aspen

are the most abundant forest cover types. Plantations of red pine are common in some areas. On wet sites the forests are of two major types: tamarack and black spruce in the peatlands, and bottomland hardwoods in the floodplains of the larger rivers. Many attempts to practice agriculture west of the Wisconsin River failed due to poor soils, poor drainage, and growing season frosts.

Socioeconomic Conditions

The counties included in this socioeconomic region are Adams, Clark, Jackson, Juneau, Monroe, Portage, and Wood.

Population

292,119; 5.1% of the state total

Population Density

48 persons per square mile

Per Capita Income

$29,022

Important Economic Sectors

The largest employment sectors in 2007 were Health Care and Social Services (13.5%), Government (13.4%), Tourism-related (10.8%), and Retail Trade (8.9%). Although Forestry and Agriculture (potato and cranberry production are important here) do not have as large an impact on the number of jobs they produce compared to other economic sectors, they are the sectors that have the largest impact on the natural resources within the ecological landscape due to their effects on land and water.

Public Ownership

Approximately one-quarter of the ecological landscape is publicly owned, very high for an ecological landscape this far south. The public lands are mostly in federal, state, or county ownership and include Necedah National Wildlife Refuge; Black River State Forest; Buena Vista, Sandhill, Meadow Valley, and Wood County Wildlife Areas; Buckhorn State Park; and Clark, Jackson, Juneau, Monroe, and Wood County Forests. A map showing public land ownership (county, state, and federal) and private lands enrolled in the forest tax programs in this ecological landscape can be found in Appendix 10.K at the end of this chapter.

Other Notable Ownerships

The Nature Conservancy has partnered with the Wisconsin Department of Natural Resources and others to develop a large conservation project at Quincy Bluff and Wetlands State Natural Area in southern Adams County. Members of the Ho-Chunk Nation have significant holdings near Black River Falls. Some of the private holdings in the Central Sand Plains are very large, especially when compared with other ecological landscapes in southern Wisconsin.

Considerations for Planning and Management

The extensive acreage of public lands and the large amount of forest cover and wetlands in the western part of the Central Sand Plains Ecological Landscape present unique opportunities for management at large scales. A small number of large private ownerships, rather than numerous small private ownerships, is a characteristic ownership pattern in some areas, and this may also facilitate management at large scales and potentially make the coordination of management on public and private lands more feasible. Integration of forest and barrens management is possible and highly desirable in some areas because of the type, suitability, and condition of the habitats present; the extensive acreage of public lands; and the relatively low levels of development. Partial restoration of some streams is possible by restoring meanders, removing dams, plugging ditches, and improving management on other lands within the watersheds. Groundwater withdrawals and

View from Bear Bluff looking west at Hunter's Peak, Winkler Hills. Note extensive forests of oak and pine. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Hydrologically intact, sedge-dominated open wetland north of Bear Bluff Road, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

contamination are concerns due to the sandy soils and high water table. Center pivot irrigation is common east of the Wisconsin River and has been increasing to the west of the Wisconsin. Use of prescribed fire as a management tool may be more feasible at large scales here than elsewhere in southern Wisconsin and is appropriate for many forest, savanna, grassland, and wetland communities. Burn plans should incorporate refugia where needed to protect fire-sensitive species. The spread of invasive plants threatens natural communities and other habitats and is a growing management concern. Commercial cranberry farming has been expanding in recent years, sometimes into upland sites rather than wetlands.

Management Opportunities

The Central Sand Plains Ecological Landscape surrounds a large acreage of publicly owned lands and contains extensive blocks of a wide variety of habitats. It provides many landscape-scale management opportunities absent from other parts of Wisconsin, especially the southern half of the state where habitats are often highly fragmented and public ownership is limited.

Large forest blocks provide habitat for area-sensitive species and protect water quality. Extensive oak and pine forests are common and can be managed at all scales and age classes. Opportunities to develop and maintain old-growth characteristics are good for Northern Dry-mesic Forest, Southern Dry-mesic Forest, the mixed Central Sands Pine-Oak Forest, White Pine-Red Maple Swamp, and Floodplain Forest as well as some of the drier oak and pine types at certain locations. Floristically rich mesic hardwood forests on terraces just above the floodplains of several of the major rivers offer fewer, but important, opportunities. Early successional forest management opportunities are also good here for jack pine, "scrub" oak, and, locally, aspen.

Abundant wetlands provide excellent large-scale management opportunities, especially in and around the bed of the former Glacial Lake Wisconsin. Large acid peatland complexes support many species (plants and animals) known mostly from northern Wisconsin, along with species that are rare in the north. These wetlands can be managed in ways that are compatible with surrounding forest and/or open habitats to maximize their utility for sensitive species.

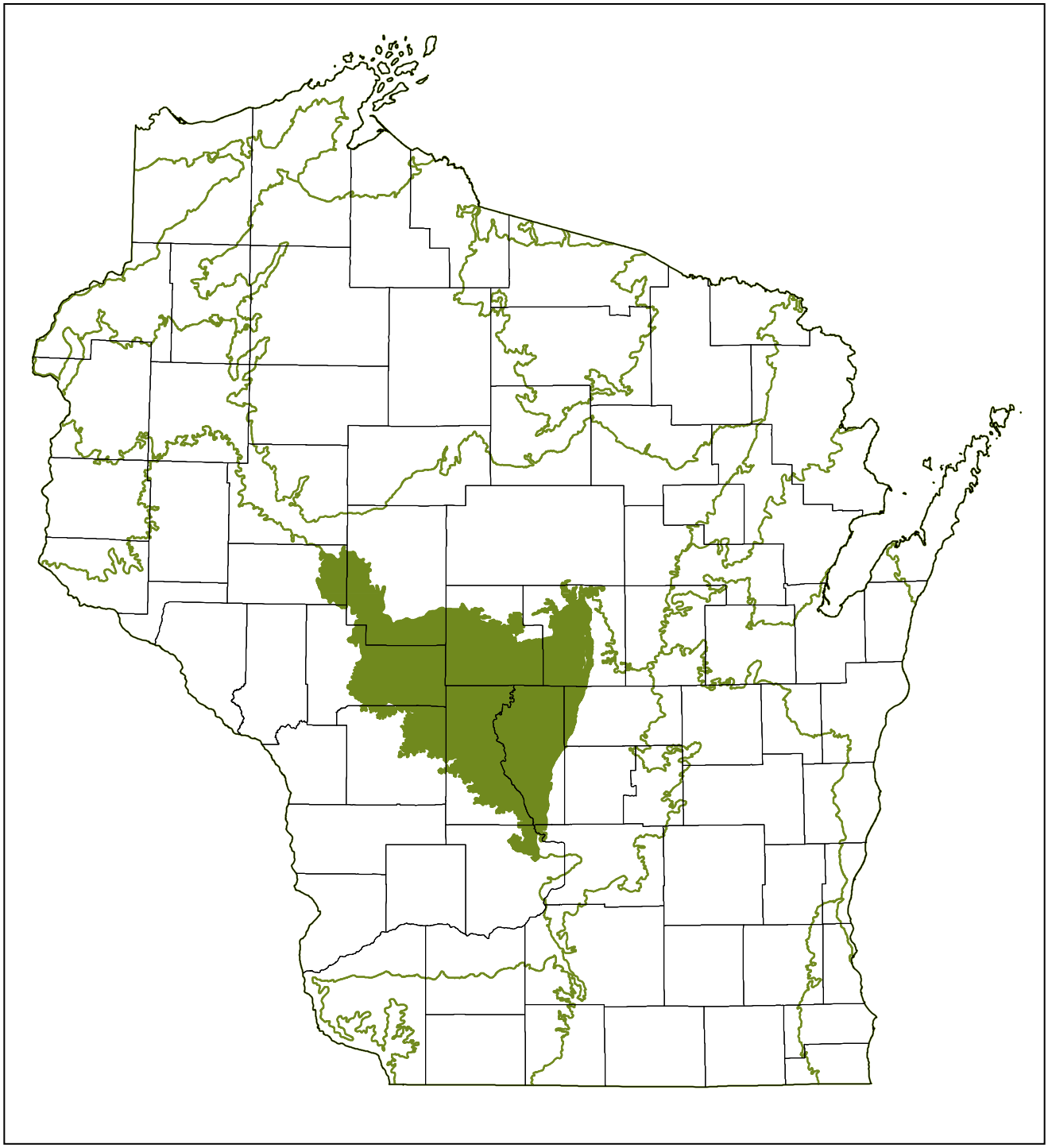
Rare communities such as Oak and Pine Barrens, Coastal Plain Marsh, and White Pine-Red Maple Swamp are well represented in the Central Sand Plains and support many rare species. Remnant barrens warrant additional recognition, protection, restoration, and expansion and in many areas could be managed compatibly with dry forests of jack pine and oak. East of the Wisconsin River, extensive "surrogate grasslands" are managed for rare and declining grassland animals, including Wisconsin's best populations of the Greater Prairie-chicken and regal fritillary butterfly. In general, there are numerous opportunities to connect high-quality remnants of barrens, dry forest, sand prairie, and other habitats and manage at multiple scales.

Major rivers such as the Wisconsin, Black, Yellow, Lemonweir, and Eau Claire and their floodplains provide extensive, contiguous habitats (especially floodplain forest) for many species of management concern. The river corridors can provide connectivity between habitats in this landscape and with other ecological landscapes to the north, south, and west. Headwaters streams originating in Central Sand Plains extensive peatlands could be restored, protected, and managed as parts of entire riparian systems—a rare opportunity for the southern half of the state.

Sandstone bedrock exposures in the Central Sand Plains include unusual features such as buttes, mesas, mounds, and pinnacles. These types of geological features are not found elsewhere in the state, and some of them support rare and specialized plants and animals.

The Central Sand Plains is a major concentration area of rare species, including several that are globally imperiled. A number of disjunct species, sometimes far from their primary ranges, are present. In addition, the landscape's location and its wide variety of habitats allow many plants and animals to occur near their southern or northern range limits.

This mixed oak and pine barrens has been restored through the use of mechanical brush and tree removal and prescribed burning. The scattered trees provide habitat for species such as Red-headed Woodpecker, Orchard Oriole, and Eastern Bluebird. Several invertebrates associated with barrens benefit from the filtered shade of the remaining trees, and many animals utilize the acorns. Photo by Armund Bartz, Wisconsin DNR.



Central Sand Plains Ecological Landscape

Central Sand Plains Ecological Landscape

Introduction

This is one of 23 chapters that make up the Wisconsin DNR's publication *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management.* This book was developed by the Wisconsin DNR's Ecosystem Management Planning Team (EMPT) and identifies the best areas of the state to manage for natural communities, key habitats, aquatic features, native plants, and native animals from an ecological perspective. It also identifies and prioritizes Wisconsin's most ecologically important resources from a global perspective. In addition, the book highlights socioeconomic activities that are compatible with sustaining important ecological features in each of Wisconsin's 16 ecological landscapes.

The book is divided into three parts. Part 1, "Introductory Material," includes seven introductory chapters describing the basic principles of ecosystem and landscape-scale management and how to use them in land and water management planning; statewide assessments of seven major natural community groups in the state; a comparison of the ecological and socioeconomic characteristics among the ecological landscapes; a discussion of the changes and trends in Wisconsin ecosystems over time; identification of major current and emerging issues; and identification of the most significant ecological opportunities and the best places to manage important natural resources in the state. Part 1 also contains a chapter describing the natural communities, aquatic features, and other selected habitats of Wisconsin. Part 2 of the book, "Ecological Landscape Analyses," of which this chapter is part, provides a detailed assessment of the ecological and socioeconomic conditions for each of the 16 individual ecological landscapes. These chapters identify important considerations when planning management actions in a given ecological landscape and suggest management opportunities that are compatible with the ecology of the ecological landscape. Part 3 of the book, "Supporting Materials," includes appendices, a glossary, literature cited, recommended readings, and acknowledgments that apply to the entire book.

This publication is meant as a tool for applying the principles of ecosystem management (see Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book). We hope it will help users better understand the ecology of the different regions of the state and help identify management that will sustain all of Wisconsin's species and natural communities while meeting the expectations, needs, and desires of our public and private partners. The book should provide valuable tools for planning at different scales, including master planning for DNR-managed lands, as well as assist in project selection and prioritization.

Many sources of data were used to assess the ecological and socioeconomic conditions within each ecological landscape. Appendix C, "Data Sources Used in the Book," (see Part 3 of the book, "Supporting Materials") describes the methodologies used as well as the relative strengths and limitations of each data source for our analyses. Information is summarized by ecological landscape except for socioeconomic data. Most economic and demographic data are available only on a political unit basis, generally with counties as the smallest unit, so socioeconomic information is presented using county aggregations that approximate ecological landscapes, unless specifically noted otherwise.

Rare, declining, or vulnerable species and natural community types are often highlighted in these chapters and are given particular attention when Wisconsin does or could contribute significantly to maintaining their regional or global abundance. These species are often associated with relatively intact natural communities and aquatic features, but they are sometimes associated with cultural features such as old fields, abandoned mines, or dredge spoil islands. Ecological landscapes where these species or community types are either most abundant or where they might be most successfully restored are noted. In some cases, specific sites or properties within an ecological landscape are also identified.

Although rare species are often discussed throughout the book, "keeping common species common" is also an important

Terms highlighted in green are found in the glossary in Part 3 of the book ("Supporting Materials"). Naming conventions are described in Part 1 in the Introduction to the book. Data used and limitation of the data can be found in Appendix C, "Data sources used in the Book," in Part 3.

consideration for land and water managers, especially when Wisconsin supports a large proportion of a species' regional or global population or if a species is socially important. Our hope is that the book will assist with the regional, statewide, and landscape-level management planning needed to ensure that most, if not all, native species, important habitats, and community types will be sustained over time.

Consideration of different scales is an important part of ecosystem management. The 16 ecological landscape chapters present management opportunities within a context of ecological functions, natural community types, specific habitats, important ecological processes, localized environmental settings, or even specific populations. We encourage managers and planners to include these along with broader landscape-scale considerations to help ensure that all natural community types, critical habitats, and aquatic features, as well as the fauna and flora that use and depend upon them, are sustained collectively across the state, region, and globe. (See Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book for more information.)

Locations are important to consider since it is not possible to manage for all species or community types within any given ecological landscape. Some ecological landscapes are better suited to manage for particular community types and groups of species than others or may afford management opportunities that cannot be effectively replicated elsewhere. This publication presents management opportunities for all 16 ecological landscapes that are, collectively, designed to sustain as many species and community types as possible within the state, with an emphasis on those especially well represented in Wisconsin.

This document provides useful information for making management and planning decisions from a landscape-scale and long-term perspective. In addition, it offers suggestions for choosing which resources might be especially appropriate to maintain, emphasize, or restore within each ecological landscape. The next step is to use this information to develop landscape-scale plans for areas of the state (e.g., ecological landscapes) using a statewide and regional perspective that can be implemented by field resource managers and others. These landscape-scale plans could be developed by Wisconsin DNR staff in cooperation with other agencies and nongovernmental organizations (NGOs) that share common management goals. Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book contains a section entitled "Property-level Approach to Ecosystem Management" that suggests how to apply this information to an individual property.

How to Use This Chapter

The organization of ecological landscape chapters is designed to allow readers quick access to specific topics. You will find some information repeated in more than one section, since our intent is for each section to stand alone, allowing the reader to quickly find information without having to read the chapter from cover to cover. The text is divided into the following major sections, each with numerous subsections:

- Environment and Ecology
- Management Opportunities for Important Ecological Features
- Socioeconomic Conditions

The "Environment and Ecology" and "Socioeconomic Conditions" sections describe the past and present resources found in an ecological landscape and how they have been used. The "Management Opportunities for Important Ecological Features" section emphasizes the ecological significance of features occurring in the ecological landscape from local, regional, and global perspectives as well as management opportunities, needs, and actions to ensure that these resources are enhanced or sustained. A statewide treatment of integrated ecological and socioeconomic opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book.

Summary sections provide quick access to important information for select topics. "Central Sand Plains Ecological Landscape at a Glance" provides important statistics about and characteristics of the ecological landscape as well as management opportunities and considerations for planning or managing resources. "General Description and Overview" gives a brief narrative summary of the resources in an ecological landscape. Detailed discussions for each of these topics follow in the text. Callout boxes provide quick access to important information for certain topics ("Significant Flora," "Significant Fauna," and "Management Opportunities").

Coordination with Other Land and Water Management Plans

Coordinating objectives from different plans and consolidating monetary and human resources from different programs, where appropriate and feasible, should provide the most efficient, informed, and effective management in each ecological landscape. Several land and water management plans dovetail well with *Ecological Landscapes of Wisconsin*, including the Wisconsin Wildlife Action Plan; the Fish, Wildlife, and Habitat Management Plan; the Wisconsin Bird Conservation Initiative's (WBCI) All-Bird Conservation Plan and Important Bird Areas program; and the *Wisconsin Land Legacy Report.* Each of these plans addresses natural resources and provides management objectives using ecological landscapes as a framework. Wisconsin DNR basin plans focus on the aquatic resources of water basins and watersheds but also include land management recommendations referencing ecological landscapes. Each of these plans was prepared for different reasons and has a unique focus, but they overlap in many areas. The ecological management opportunities provided in this book are consistent with the objectives provided in many of these

plans. A more thorough discussion of coordinating land and water management plans is provided in Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book.

General Description and Overview

The Central Sand Plains Ecological Landscape is located in central Wisconsin, around a relatively level, sandy, glacial lake plain. Important land uses include recreation, wildlife management, forestry, and agriculture. This ecological landscape formed in and around what was once Glacial Lake Wisconsin, which at its highest stage contained glacial meltwater that covered over 1.1 million acres (see map of Glacial Lake Wisconsin in the "Landforms and Surficial Geology" section below). Soils are primarily sands, including lacustrine deposits, glacial outwash, and material eroded from the underlying sandstone bedrock. Organic soils are common in the extensive poorly drained peatlands. Sandstone mesas, buttes, pinnacles, and cliffs were created by wind, wave, and ice action in and around Glacial Lake Wisconsin, and the catastrophic drainage of Glacial Lake Wisconsin carved spectacular sandstone gorges in some parts of the ecological landscape. No other part of Wisconsin has similar geological features.

The historical vegetation of this area included some of Wisconsin's most extensive wetlands, especially within and on the margins of the old glacial lakebed. Silts and clays on the lake's bottom impeded drainage in many places. Large areas of bog, fen, sedge meadow, muskeg, and conifer swamp comprised the prevalent wetland vegetation. On the uplands there were extensive areas of pine and oak forests. Areas that burned frequently were vegetated with pine barrens, oak barrens, and sand prairie. Limited areas of more mesic hemlock hardwood forest were present, usually around the ecological landscape's edges. A large pinery of major commercial importance occurred in eastern Jackson County (Eswein 1995). The northwestern part of the ecological landscape includes areas of rougher topography. However, it is sandy and supports extensive forests and wetlands that are similar to those occurring farther south and east. Mixed pine and oak barrens occurred in what is now eastern Eau Claire County.

Today the western portion of the ecological landscape contains extensive forests of oak and pine, abundant peatlands, and large public ownerships. Human population density remains low, and associated infrastructure is limited. Early in the 20th century, many of the wetlands west of the Wisconsin River were drained for agriculture, but, with the notable exception of commercial cranberry production, many attempts to farm this area failed. Widespread wetland drainage occurred at about the same time in the eastern part of the ecological landscape, and these lands are now used mostly for agricultural purposes, including the production of corn, soybeans, potatoes, small grains, vegetables, and as pastureland. Recently, some commercial cranberry bed development has occurred on uplands east of the Wisconsin River. Public lands are less extensive east of the Wisconsin River than to the west, but there are significant acreages of nonnative grass that are managed to benefit rare grassland birds such as the Greater Prairie-Chicken (*Tympanuchus cupido*).

The largest and most significant rivers that flow through this ecological landscape include the Wisconsin, Black, East Fork of the Black, Yellow, Plover, and Lemonweir. All of the larger rivers (and some of the smaller streams) are associated with significant floodplains, which are mostly forested with lowland hardwoods. There are no large natural lakes here, although there are riverine lakes within the larger floodplains and scattered natural ponds. Impoundments are numerous. Most of the natural lakes are associated with the larger river floodplains, and these provide important habitat for fish, herptiles, birds, and invertebrates. Rivers and streams of this ecological landscape are relatively unpolluted, although there are significant exceptions, including the Wisconsin River and some of its tributaries. However, nonpoint pollution rankings from the Wisconsin DNR indicate that watersheds in the more agricultural eastern half of this ecological landscape are highly susceptible to groundwater contamination from nonpoint sources compared to other parts of Wisconsin. In parts of the Central Sand Plains, sandy soils on top of sandy glacial deposits allow water and waterborne contaminants to infiltrate quickly to the groundwater (WGNHS and Wisconsin DNR 1989). Only the Central Sand Hills Ecological Landscape has comparable nonpoint groundwater pollution susceptibility ranking.

The principal land uses within the Central Sand Plains counties (Adams, Clark, Jackson, Juneau, Monroe, Portage, and Wood) are agriculture, including cranberry production, recreation, and timber production. Some of these counties are among Wisconsin's top producers of crops such as potatoes (these counties combined produce half of the state's potatoes) and cranberries. Jackson and Wood counties are the top cranberry producers in the state. The pulp and paper industries are primary contributors to the forest products and processing industries in the Central Sand Plains counties, accounting for 17% of the region's industrial output. This is 8% of total statewide output from these sectors.

In the Central Sand Plains Ecological Landscape, there is a 31% higher percentage of forestland and a 25% lower percentage of agricultural land compared to the rest of the state. See the "Socioeconomic Characteristics" section of Chapter 3, "Comparison of Ecological Landscapes," in Part 1 of the book for comparisons of forestland and agricultural land acreage among ecological landscapes. The percentage of surface area in water is fourth highest in the state of the 16 ecological landscapes, mainly due to several huge impoundments on the Wisconsin River and the aggregate acreage of surface water in the numerous impounded streams and wetlands. The amount of public land is much higher here than in other parts of southern Wisconsin. The density of campgrounds is higher than average, as is the number of visitors to state lands. Trail

density, however, is low compared to other ecological landscapes. There is a lower density of hiking, road biking, ATV, and snowmobiling trails compared to the rest of the state. Acreage in State Natural Areas is much higher than average, but the number of Land Legacy sites with high recreation potential is low. These counties rank 12th out of 16 ecological landscapes in trail density (miles per 100 square miles).

The Central Sand Plains counties are rural in character, with many small cities and towns. The mean population density of the Central Sand Plains counties (48 persons per square mile) is less than half that of the state as a whole (105) (USCB 2012b). Property values, on average, are among the lowest of all ecological landscape county approximations in the state. In general, the region is homogeneous in racial composition and exhibits an age distribution slightly skewed towards an older population. Education attainment in Central Sand Plains counties is lower than the statewide average.

Environment and Ecology

Physical Environment

Size

The Central Sand Plains Ecological Landscape encompasses 3,420 square miles (2,188,861 acres), representing 6.1% of the land area of the state of Wisconsin.

Climate

Climate data were analyzed from 10 weather stations within the Central Sand Plains Ecological Landscape (Fairchild Ranger Station, Hancock Experimental Farm, Hatfield Hydro Plant, Mather, Mauston, Necedah, Pittsville, Stevens Point, Wisconsin Dells, and Wisconsin Rapids). The Central Sand Plains has a continental climate, with cold winters and warm summers, similar to other southern Wisconsin ecological landscapes. The southern ecological landscapes in Wisconsin generally tend to have longer growing seasons, warmer summers, warmer winters, and more precipitation than the ecological landscapes farther north. Ecological landscapes adjacent to the Great Lakes generally tend to have warmer winters, cooler summers, and higher precipitation, especially lake effect snow.

Cranberry beds and ditch in central Wisconsin. Photo by Wisconsin DNR staff.

The mean growing season in the Central Sand Plains (135 days; base 32°F) is almost 19 days less than other southern Wisconsin ecological landscapes (154 days). ***Mean growing degree days*** varies considerably among weather stations within the Central Sand Plains (112 to 148 days). Generally, mean growing degree days are fewer at weather stations west of the Wisconsin River (130 days) than east of the river (141 days). Local topography seems to affect the mean number of growing degrees in this ecological landscape more than latitudinal gradient. Low-lying areas (e.g., Necedah, 123 days, and Pittsville, 124 days) tend to have fewer growing degree than areas to the north (e.g., Steven Point, 148 days) or to the south (e.g., Wisconsin Dells, 137 days). Summer temperatures can be cold or freezing at night in the lower-lying areas of this ecological landscape. Climate records from the Necedah station indicate extreme minimum temperatures of 28°F for the months of June and August. A soil survey of Juneau County, conducted by the Wisconsin Geological and Natural History Survey and the U.S. Department of Agriculture in 1914, noted that "in the low marshy areas the probability of the occurrence of frosts during summer months should be kept in mind, for it may be a determining factor in selecting a type of farming best suited to prevailing conditions" (WGNHS 1914). The 1924 Adams County Soil Survey also warned of frosts on "Marsh Land" (WGNHS 1924).

Mean annual temperature is 43.8°F, about one degree cooler than other southern ecological landscapes (44.9°F). The average January minimum temperature is 2.5°F, almost one degree cooler than other southern ecological landscapes (3.2°F). The average August maximum temperature is 80.7°F, very similar to the other southern ecological landscapes (80.9°F).

Mean annual precipitation is 32.8 (31.6–34.0) inches, an average value compared with the rest of the southern ecological landscapes (33.1 inches). The mean annual precipitation varied little (2.4 inches) among weather stations within this ecological landscape. Mean annual snowfall is 45 inches, ranging from 31.4 inches to 54.6 inches, similar to other southern Wisconsin ecological landscapes (41.7 inches). Although the amount of annual snowfall varied by almost 23 inches among weather stations within the ecological landscape, no discernible patterns of snowfall were evident.

The short growing season, occasional freezing temperatures during summer, sandy soils, and abundance of wetlands in this ecological landscape limit agriculture west of the Wisconsin River. The growing season is somewhat longer (11 days) east of the Wisconsin River with less potential for growing season frosts. Agriculture is more prevalent here, with an emphasis on cool season crops such as potatoes, vegetable crops, and early maturing corn. Center pivot irrigation is used because of the sandy soils and shallow aquifers.

Livestock grazing is important in some areas. The occurrence of some plants is restricted by the short growing season, poor soils, and summer frosts, all of which influence the region's ecology.

Bedrock Geology

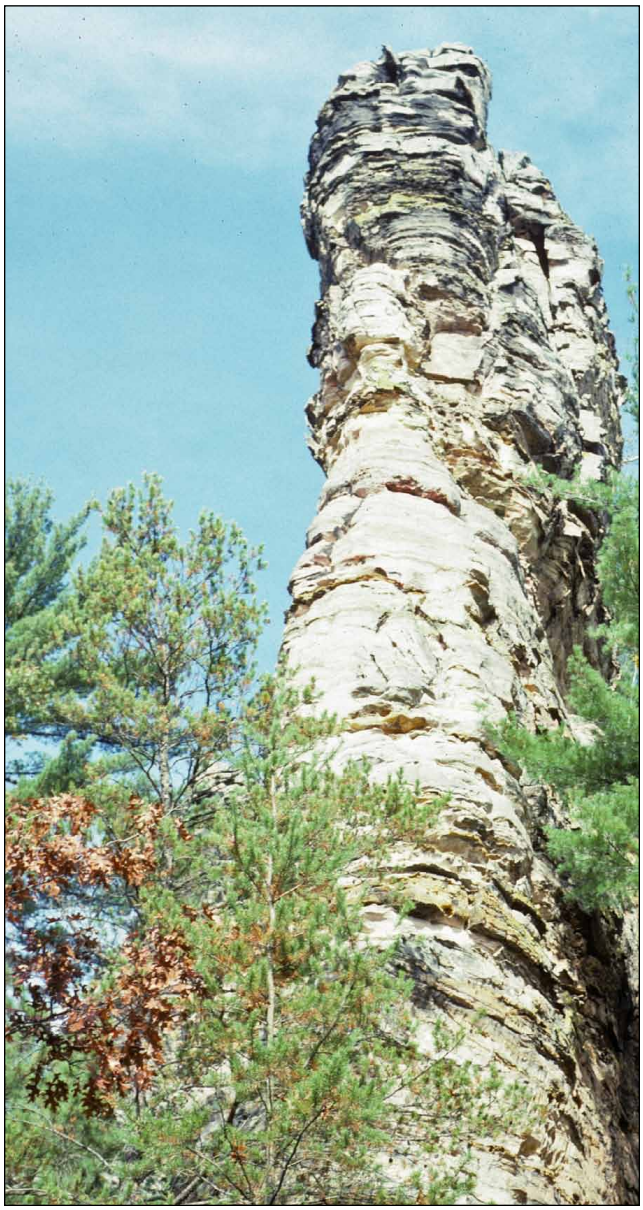
The Central Sand Plains Ecological Landscape is underlain by Late Cambrian sandstone that contains strata of dolomite and shale. Precambrian igneous and metamorphic rocks lie beneath the Late Cambrian sandstone, and these rocks are exposed in only a few places in the ecological landscape. Lower portions of the Cambrian sandstone are believed to have been formed by windblown sand because these rocks exhibit large crossbedding—thick strata with diagonal patterns formed as sand was deposited on the sloping sides of ancient dunes (Dott and Attig 2004). Starting around 500 million years ago, the area was slowly inundated by a Cambrian ocean, and marine sandstone with relatively uniform horizontal bedding was deposited over the windblown material. The Cambrian Formation is important as the primary source of groundwater in the area.

Outcrops of Late Cambrian sandstone are scattered throughout this ecological landscape, protruding from the level sand plains as bluffs or buttes, many of them with sides dramatically sculpted by wind and water. Most of these exposures are around 100 feet higher than the surrounding plain, but some rise up to 300 feet. The Cambrian sandstone is made up of several different geologic formations. (Nomenclature used herein is according to the Wisconsin Geological and Natural History Open-File Report "Bedrock Stratigraphic Units in Wisconsin" [WGNHS 2006].) The lowermost is the Mt. Simon Formation, a whitish-colored layer several hundred feet thick, composed of fine- and medium-grained sands and typically without fossils. It is mostly cemented by silica and thus is noncalcareous. Abundant large-scale crossbedding is indicative of its nonmarine deposition (Dott and Attig 2004). In some locations, it includes strata of silt and shale that were deposited by streams running between ancient dunes. The Mt. Simon Formation is a significant aquifer (Clayton 1987, Clayton 1989).

The Eau Claire Formation is a thin layer of only 10–20 feet that lies above the Mt. Simon Sandstone. It is very fine- to medium-grained, horizontally thin- to medium-bedded brownish sandstone. This formation is fossiliferous, of marine origin, and contains a few strata of shale. It is a layer that constrains the underlying aquifer. The Wonewoc Formation lies atop the Eau Claire Formation. It is up to about 75 feet thick, a fine- to medium-grained, brownish-yellow to yellow sandstone. The top portion of the Wonewoc sandstone tends to form steep cliffs with near-vertical faces. The Wonewoc Formation is also an aquifer.

Cambrian deposits more recent than the Wonewoc have been eroded away in nearly all locations in the Central Sand Plains. In only a few places, such as Quincy Bluff in Adams County, younger deposits are exposed atop the Wonewoc Formation. These include the Tunnel City Group, about 100 feet thick, containing ***glauconitic strata*** and a shaly layer at the base; the St. Lawrence Formation, about 30 feet thick, of yellowish sand with thin limestone beds; and the Jordan Formation of reddish brown sand, up to around 30 feet thick.

Cambrian sandstone is also exposed along some riverbanks in the ecological landscape, including the Black River and the East Fork of the Black River, where it outcrops as low ledges or cliffs. Precambrian-age igneous and metamorphic rocks are also exposed along the Black River, the East Fork of the Black River, and at Battle Point, and a pinkish quartzite is exposed at Necedah Bluff. These are some of the southernmost exposures of Precambrian rocks in Wisconsin.



Bedrock features such as this Cambrian sandstone pinnacle occur in few other ecological landscapes in Wisconsin. Adams County. Photo by Eric Epstein, Wisconsin DNR.

In eastern Jackson County, some sandstone buttes have cores of low-grade iron ore that has been mined intermittently. Mining first occurred in the 1850s, later in the 1880s, and most recently in the 1970s but has been only marginally profitable (Langton and Simonson 1998).

In most of the Central Sand Plains Ecological Landscape, bedrock is buried beneath sandy drift material that can be up to several hundred feet thick. The thickest glacial drift deposits occur in the eastern part of the ecological landscape; in the western portion, most drift is less than 50 feet thick (WGNHS 1983).

Landforms and Surficial Geology

This ecological landscape is a large, flat expanse of lacustrine and outwash sand, distinctive from any other part of the state in its origin as an extremely large glacial lake (Figure 10.1). The sand was deposited in Glacial Lake Wisconsin, along with outwash sand derived from glaciers to the north. The occurrence of such a large glacial lake is an uncommon event in the history of glaciation.

Glacial Lake Wisconsin came into existence about 19,000 years ago when the Green Bay lobe of the Wisconsin glaciation advanced onto the east end of the Baraboo Hills and blocked the ancient river that ran through the valley now occupied by the Wisconsin River. Glacial ice lay along the eastern edge of the Central Sand Plains, blocking outflow in that direction, while higher elevations to the north and south forced the rising water to inundate land to the west. A number of ***tunnel channels*** emptied out of the glacial lake from beneath the ice sheet. Many of the sand and gravel quarries in the Johnstown Moraine east of Interstate 39 are located where tunnel channels emerged from beneath the glacier. Meltwater from glaciers to the north also moved sand into the lake; ***braided stream*** sediments from this period are found on terraces along the Wisconsin River in Juneau County (Clayton 1989). Glacial meltwater is also rich in silt, and Glacial Lake Wisconsin was sufficiently deep and still for silty lacustrine materials to accumulate extensively in the lakebed. The silt layer was subsequently covered with sand but is near the surface in west-central Adams County where much of the sand was blown away after the lake drained. The silty layer is typically 1.5 to 16 feet thick, and occurs at depths of 10 to 75 feet. Other silt layers may be present as deeper-lying strata, but their occurrence and extent is unclear (Clayton and Attig 1989). Where silty layers are near the surface, they impede moisture drainage, contributing to the formation of wetlands (Gundiach et al. 1991). In areas where silt layers are more deeply buried, the water table is mainly controlled by the elevation of the Wisconsin River; the relatively flat topography and low elevation of the ecological landscape allow water to collect here.

The size of Glacial Lake Wisconsin varied over time depending on the position of glacial ice, changes in climate that influenced the amount of water coming into the lake, and downcutting of outlets to the west. The lake was large—70 miles long and 160 feet deep at its maximum extent—and existed at various stages for approximately 5,000 years. During most of this time, meltwater drained through the lowland now occupied by the

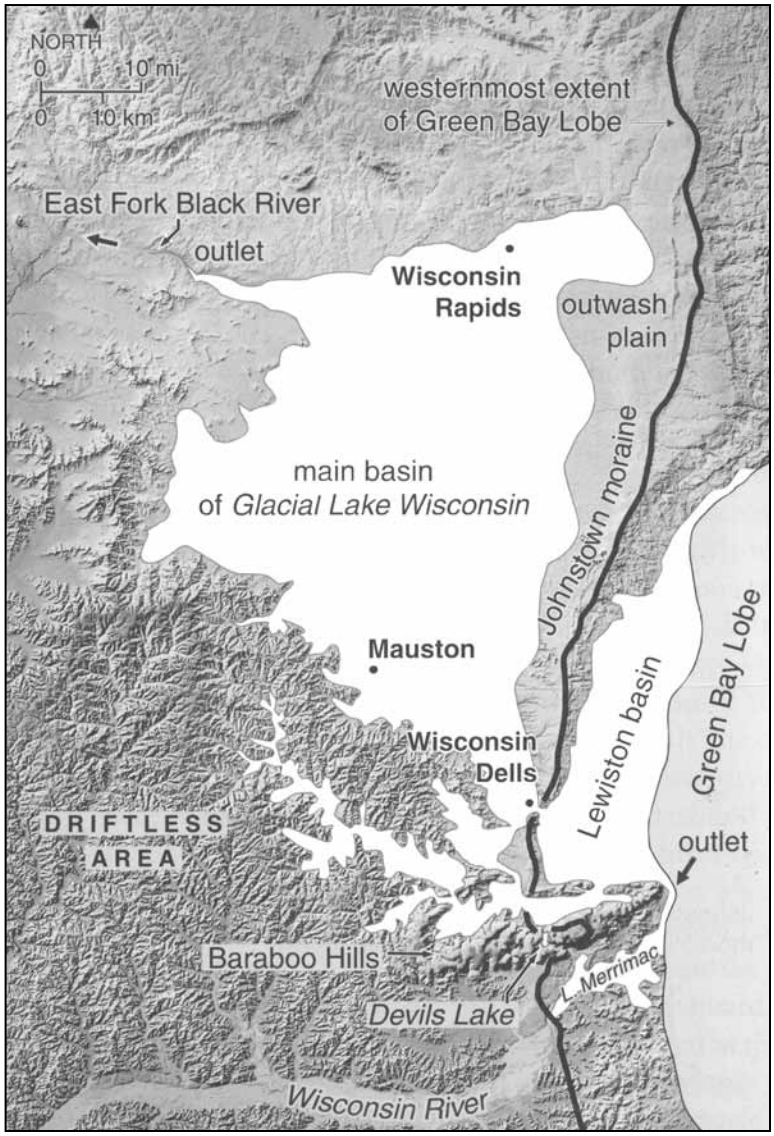


Figure 10.1. *Glacial Lake Wisconsin. Toward the end of the Wisconsin glaciation, between 19,000 and 14,000 years ago, much of central Wisconsin was occupied by a huge proglacial lake called Lake Wisconsin. At its greatest extent, this lake was over 115 km long, with a maximum depth of over 50 m. The drainage of Glacial Lake Wisconsin was sudden and probably catastrophic, occurring within a period of just a few days about 14,000 years ago. Figure reproduced from Dott and Attig,* Roadside Geology of Wisconsin *(Missoula: Mountain Press Publishing Co., 2004), 203.*

East Fork of the Black River, continuing through the Black River valley to the Mississippi River. Drainage channels of the lake are found in southwestern Wood County, in the Wood County Wildlife Area. Most of the former drainage channels have been obscured by deposits of postglacial sediments, so their exact location is uncertain (Clayton and Attig 1989).

By about 14,000 years ago, the climate had warmed sufficiently for the glacial ice to thin and soften at the margin of the Green Bay lobe, and the ice dam that held Glacial Lake Wisconsin was breached at the east end of the Baraboo Hills. The lake drained rapidly and with considerable force; water levels dropped by 100 feet in a few days, and the flood built a delta that contained boulders as large as 5 feet in diameter (Clayton and Attig 1989).

Earlier glacial lakes, formed by glaciers that preceded the Wisconsin glaciation, are believed to have built lake plains and other drainage features in the western part of the ecological landscape, beyond the extent of Glacial Lake Wisconsin. The large sand plain that makes up most of the Black River State Forest, known as the Jackson Plain, may have been covered by one or more extensive glacial lakes prior to 130,000 years ago (Clayton and Attig 1989). The deep sand deposits in this area are originally hillslope sediments eroded from the sandstone bedrock by wind and by the water of glacial lakes.

After the Wisconsin glaciation, and before vegetation covered the land, there was little to impede strong winds throughout the region. The sandy surfaces of the lake plains and outwash terraces were easily moved about, and many aeolian dune features were built by wind action. Geologic maps identify areas of thick windblown sand deposits and dunes of up to 60 feet in height; these are common in the area along the east side of the Wisconsin River in Adams County (Clayton 1987). Lesser dunes are also striking features in parts of Juneau County such as those found in the southern portions of the Necedah National Wildlife Refuge and Meadow Valley Wildlife Area. In addition to postglacial wind action, the downcutting and redeposition of stream materials formed floodplains, terraces, and swamps along the major rivers.

The northwestern portion of the ecological landscape (in the Neillsville Sandstone Plateau, Subsection 222Rb) was formed by different geomorphic processes. (For details on Subsections, see the "Introduction" in Part 1 of the book and the "National Hierarchical Framework of Ecological Units" map [Cleland et al. 1997] in Appendix G, "Statewide Maps," in Part 3 of the book, "Supporting Materials"). The landscape is an undulating surface of soil materials eroded from hillslopes, lying over Precambrian and Cambrian bedrock that was worn away and smoothed by erosion during the late Precambrian and early Paleozoic and by glaciation during the Pleistocene. The hillslope sediment was mostly deposited during the period of the Wisconsin glaciation. Above Cambrian sandstone, the sediment is dominantly sandy and relatively thin, while the sediment over Precambrian rock is loamy material derived from till, typically 10–13 feet thick.

These dunes were created by wind action after Glacial Lake Wisconsin drained. The dunes now support barrens vegetation or xeric stands of pine and oak; the hollows between the dunes support various wetland types. Photo by Eric Epstein, Wisconsin DNR.

The sediment was transported downslope by running water or, particularly during periods of tundra climate, by mass wasting. This type of erosion, called ***solifluction***, occurs when the land surface melts during the summer, becoming saturated and muddy, and then slides downhill over the underlying permafrost. Loess deposits of windblown silt about 1.5 feet thick were deposited after the hillslope sediment, although the materials are now mixed in some places by animal burrowing or windthrown trees (Clayton 1991).

A map showing the ***Landtype Associations*** (Wisconsin Land Type Association Project Team 2002) in this ecological landscape, along with the descriptions of the Landtype Associations, can be found in Appendix 10.K at the end of this chapter.

Topography and Elevation

Land surface elevations in the Central Sand Plains are mostly between 850 and 900 feet, with a range of 722 to 1,409 feet. The lowest spot is along the Black River south of Black River Falls and the highest is at the top of Saddle Mound in eastern Jackson County along Wisconsin Highway 54. Elevations in the lakebed of the former Glacial Lake Wisconsin are lowest along the Wisconsin River and tend to rise gradually toward the borders of the ecological landscape. The Central Sand Plains has a relatively low elevation compared with the rest of the state, except for its mounds and buttes, due to the character of the underlying bedrock and the effects of erosion and multiple glacial events.

Topography throughout most of the ecological landscape is typical of outwash and lake plains, where the land surface is flat, nearly level, or gently sloping. Striking topographic features here are the scattered steep-sided and very steep sandstone buttes and pinnacles that protrude through the sandy plains. Some topographic relief is also provided by dunes and stream valleys.

In the northwestern portion of the ecological landscape, the landscape is mostly undulating. Here, gentle hills are formed by the underlying bedrock surface, and stream action has formed valleys and floodplains. Wetlands are common here, with water tables held up by underlying bedrock.

Soils

Most soils in the ecological landscape were formed in deep sand deposits of glacial lacustrine or outwash origin or in materials eroded from sandstone hillslopes, sometimes with a surface of wind-deposited (aeolian) sand. These deep sandy soils are typically excessively drained, with very rapid permeability, very low available water capacity, and low nutrient status. In lower-lying portions of the ecological landscape, and where silty lacustrine material is close to the surface and impedes drainage, the water table intercepts the surface. Such areas are extensive in the western part of the ecological landscape, where soils may be poorly or very poorly drained with surfaces of peat, muck, and mucky peat. Thickness of these peat deposits ranges from a few inches to more than 15 feet (Gundiach et al. 1991). Soils are classified in the ***soil suborders Psamments, Orthods, Aquents, Aquods,*** and ***Saprists***. The eastern part of the ecological landscape in Adams County is near the Johnstown Moraine, where outwash sand deposits are thicker and soils are higher above the water table. Here, many wet soils were ditched and drained and are now commonly irrigated for the growth of vegetable crops. Irrigated land in Adams County increased from 943 acres in 1959 to more than 62,000 acres in 2002 (Jakel 1984, UWEX 2004). Ditching and drainage has also taken place in other parts of the ecological landscape, and soil disturbance to create cranberry beds is locally common. At the time of the first Juneau County Soil Survey (WGNHS 1914), a number of ditches had already been constructed in the peatlands, but drainage was said to be "not sufficiently thorough," and ditch deepening was recommended. The Wisconsin Land Economic Inventory described the same area of northern Juneau County twenty years later: "250 miles of ditches have lowered the water table six to twelve feet… and have ruined the sand peat plain for cranberries, sphagnum, and marsh hay" (Bordner et al. 1934). The survey authors noted that much of the peat surface had been burned or blown away, exposing bare sand.

On the protruding hills of remnant Cambrian sandstone, soils are formed in sandy and loamy materials weathered from the bedrock (i.e., ***residuum*** or ***colluvium***). Bedrock is often near the surface. These soils are classified in the soil suborders Psamments, ***Udalfs***, and ***Udepts***. They generally have sand to silt loam surface textures, drainage classes ranging from excessively drained to moderately well drained, rapid to moderate permeability, and low to moderate available water capacity.

In the northwestern portion of the ecological landscape, in the Neillsville Sandstone Plateau Subsection (222Rb), most soils formed in sandy or loamy hillslope alluvium or colluvium over Cambrian and Precambrian bedrock. These soils are typically somewhat poorly drained and sandy with a loamy fine sand surface, classified in the soil suborders Aquods, Aquents, ***Aquepts***, Orthods, and Udalfs.

In major river valleys throughout the ecological landscape, soils were formed in sandy to clayey ***alluvium*** (Aquents, Psamments, ***Aquolls***, and Udalfs). Their drainage classes range from moderately well drained to very poorly drained, and some areas are subject to periodic flooding.

Hydrology

Basins

The Central Sand Plains Ecological Landscape overlies much of two major water basins: the Central Wisconsin River basin and the Black River basin. It also encompasses the northern part of the Lower Wisconsin River basin, and the extreme southeastern corner of the Lower Chippewa River basin. Thirty watersheds lie wholly or partially within this ecological landscape. These watersheds and their groundwater quality rankings are listed in Appendix 10.A at the end of this chapter.

The hydrology of the Central Sand Plains is characterized by large areas of wetlands and a large number of generally low-gradient streams that range from small coldwater streams to large warmwater rivers. Natural lakes are few, and most are shallow (4–6 feet deep). The most common types of natural lakes are small shallow seepage ponds and oxbow lakes (cut-off meanders) within the floodplains of the larger rivers. Large dams in this ecological landscape have created some of Wisconsin's largest impoundments. The Wisconsin is the largest river that flows through this ecological landscape. Other significant rivers here are the Black, East Fork of the Black, Yellow, Plover, and Lemonweir.

The rapid drainage of Glacial Lake Wisconsin cut into Cambrian sandstones near Wisconsin Dells at the southern end of the ecological landscape, creating deep gorges and extensive bedrock exposures. Dell Creek, a tributary of the Wisconsin River near Wisconsin Dells (Sauk County), has been impounded to create Mirror Lake and Lake Delton. Other less spectacular sandstone gorges occur south of Lake Arbutus along the lower reaches of several Black River tributaries, such as Morrison, Halls, Valentine, Dickey, and Perry creeks in Jackson County.

Hydrologic alterations are widespread and common. The postglacial hydrology has in some locales been significantly disrupted by drainage or dike construction to create both agricultural fields and cranberry beds. Extensive ditching has occurred throughout this landscape. Some ditches have been plugged and dikes constructed to aid in the production of cranberries or to create habitat for waterfowl. Some of these impoundments are quite sterile because the water can be highly acidic, low in oxygen levels, and deficient in nutrient availability. In general, fertility and natural productivity of the waters away from the larger rivers is very low. In eastern Jackson County, an area that historically contained one of the state's major pineries, extensive systems of small canals were

dug to facilitate the transport of logs from the "Great Swamp of Central Wisconsin" to the larger rivers (see the map of the Great Swamp, Figure 10.2, in the "Wetlands" section below).

Important lake and stream biota are highlighted in the "Significant Fauna" section below.

Inland Lakes

Natural bodies of standing water in this ecological landscape are rare and limited to riverine lakes associated with the broad floodplains of the major rivers, a few small boggy ponds with waters stained by tannic acids, and miscellaneous other situations. Only 37 named lakes occur in the Central Sand Plains Ecological Landscape.

There are an additional 9,068 unnamed "lakes," most of them very small ponds that collectively cover only around 21,200 acres and are in fact mostly impoundments, ***borrow pits***, farm ponds, or other constructed features. ***Oxbow lakes*** occur along abandoned channels of many of the larger rivers and streams, and some of them support important assemblages of invertebrates and amphibians and of other animals that feed on these organisms. Riverine lakes, which are associated mostly with the larger rivers, are important for some of the same reasons and are also significant to fish because of their periodic connection to a river. A cluster of natural ponds east of Black River Falls on the Jackson County Forest supports rare plants and invertebrates. Remote Goodyear Lake in eastern Jackson County and some associated ditches support a diverse assemblage of aquatic invertebrates. Goodyear Lake is small, shallow, and embedded within a huge peatland complex. Borrow pits dug to provide sand for road or dike construction are common, and many of these have filled with water because of the high water table.

This ecological landscape is characterized by many small impoundments ("flowages"), established mostly as reservoirs for use by the cranberry industry and as habitat for waterfowl (see the "Impoundments" section below). There are no Great Lakes Indian Fish and Wildlife Commission or Wisconsin DNR-designated wild rice lakes here, although Mirror Lake, a Sauk County impoundment, does have an introduced population of wild rice.

Away from the large rivers, natural lakes are rare in the Central Sand Plains. Deer Lake is a small seepage pond within an extensive area of open meadow and poor fen. Eastern Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Portions of old drainage ditches dug for agricultural purposes no longer flow, exhibit some lake-like characteristics, and support faunas that may somewhat resemble those found in small lakes and ponds.

Impoundments

Impoundments are created when streams are dammed to generate power (Andrae 1986), provide recreational opportunities for boaters, store water for use in the commercial production of cranberries, and create habitat for selected animals such as Canada Goose (*Branta canadensis*). In the past, waters were also impounded to aid in the transport of timber. Many of the dams in the eastern portion of this ecological landscape are associated with drainage ditches. In addition to their primary purpose of making former wetlands suitable for agricultural use, water stored in the ditches was used to fight fires early in the 20th century (Goc 1990).

The Central Sand Plains has the fifth largest number of dams (479) of any ecological landscape in Wisconsin. Twenty-two other dams have been removed for safety and financial reasons and to restore impaired aquatic habitats by allowing streams to flow freely.

The construction of large power dams on the Wisconsin River has created two of the three largest impoundments in the state, the 23,000-acre Petenwell Flowage and 13,950-acre Castle Rock Flowage. Concurrent with providing hydropower, these impoundments also support recreational fishing as well as terrestrial-based recreation on adjoining uplands acquired for the hydroelectric projects as early as 1926. The Black River has been dammed at Black River Falls and near Hatfield, creating Lake Arbutus. Dams are also present on the Yellow, Plover, Eau Claire, and the South Fork of the Eau Claire rivers as well as on many smaller streams.

Within the Black River State Forest in the western part of the ecological landscape, many small streams were impounded and dikes constructed to "restore" partially drained wetlands and to increase the amount of waterfowl habitat. These impoundments are generally shallow (with a maximum depth of only 3–10 feet), infertile, and acidic, with water stained by the tannic acids present in the organic soils (Wisconsin DNR 2007). Similar impoundments have been constructed on State Wildlife Areas (e.g., at Dike Seventeen, Sandhill, Meadow Valley, and Wood County) and at Necedah National Wildlife Refuge. American beaver (*Castor canadensis*) have also impounded many streams and ditches, although their dams are less permanent.

The cranberry industry has a long history in the parts of this ecological landscape that have proven to be most challenging for other agricultural endeavors. Roughly 18,000 acres of cranberry beds exist statewide in approximately 19

counties. Much of this acreage is in the Central Sand Plains, especially in Wood, Jackson, Juneau, and Monroe counties (Wisconsin State Cranberry Growers Association 2008). Several thousand acres of expansion are expected over the next several years. The beds in which the berries are grown are supported by extensive impoundments that provide water to float the berries at harvest time and as a source of water with which the plants may be sprayed to protect them during growing season frosts.

Impoundments both large and small comprise the majority of lacustrine surface water features—in both numbers and acreage—in the Central Wisconsin River basin portion of this ecological landscape. Impoundments are similarly common in the other basins in this ecological landscape. Many of these waters are eutrophic and demonstrate excessive growth of undesirable aquatic plants because of nonpoint pollution (Wisconsin DNR 2002b). Summer blooms of toxic blue-green algae have been especially troublesome. In the Wisconsin River proper, problem nutrients include phosphorus and nitrates. Low levels of dissolved oxygen compound the negative impacts associated with excess nutrient inputs. The portion of these nutrients that are not broken down by the biological activity in the flowing sections of the river often accumulate in downstream impoundments, namely the major surface waters of Castle Rock Flowage and Petenwell Flowage. Similar problems have been documented elsewhere in the Central Wisconsin River basin as well as in some waters of the Black River and Lower Wisconsin River basins.

Home development pressures in this ecological landscape are increasing, with numerous ads, websites, and billboards offering land along or near the larger impoundments. In part to help meet the recreation needs of non-landowners in this ecological landscape and to reserve habitat for wildlife, there has been progress in obtaining easements and other land rights for public conservation purposes, especially along shorelines and in areas that adjoin existing public lands.

Rivers and Streams

Some 2,710 miles of perennial streams originate in and/or flow through the Central Sand Plains Ecological Landscape, including about 80 miles of the middle portion of the Wisconsin River, 50 miles of the Yellow River, and 30 miles of the Black River. As noted above, 479 dams impound stretches of various waterways, and these often have negative impacts on water quality and aquatic habitat. Stream restoration and dam safety concerns have led to the removal of 22 dams, as of 2007.

In some watersheds, such as the lower Yellow River and in the eastern tributaries to the Wisconsin River, many streams were ditched and channelized in an attempt to drain wetlands, lower the water table, and speed the movement of water off of the land to establish and facilitate agricultural uses. Some streams have been drastically altered by past channelization or other activities. It is currently not feasible to obtain the data needed to establish a water quality-based current use classification for these streams (see the "Aquatic Communities" section of Chapter 2, "Assessment of Current Conditions," in Part 1 of the book for information on stream use classification).

Many streams here do exhibit good water quality, and some support populations of rare fish such as the river redhorse (*Moxostoma carinatum*), gilt darter (*Percina evides*), and redfin shiner (*Lythrurus umbratilis*) (all listed as Wisconsin Threatened). (See the "Fauna" section below for additional details.) Forested watersheds and large areas of relatively intact wetlands in some portions of this landscape help to protect water quality and base flow. On the Wisconsin River, however, industrial effluent from paper mills historically introduced contaminants such as polychlorinated biphenyls (PCBs), lead, and excess nutrients into the river. While the implementation of water quality protection laws has prompted progress in cleaning up some of this pollution, the biological communities of the polluted streams have not fully recovered. Excessive nutrient inputs from nonpoint sources are now a major contributor to diminished water quality.

This stretch of the Black River is bordered by extensive upland forests of oak and pine. Floodplain development is limited, and sandstone cliffs are locally common. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Sand-bottomed, spring-fed coldwater stream with clear, amber-colored water stained by peat. Wetlands pictured here include Alder Thicket, White Pine-Red Maple Swamp. Robinson Creek, Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Groundwater drawdowns are impacting some streams in this ecological landscape due to the highly permeable soils. The state Groundwater Advisory Committee in 2006 designated the Little Plover River, a Class I trout stream, as a Groundwater Attention Area (GAA) because of low flows caused by the withdrawal of water to irrigate agricultural crops and by municipal and industrial groundwater uses (Kraft et al. 2012). Some stretches of the Little Plover were reported to have completely dried up in recent years. This designation has resulted in further studies to better quantify the relationship between groundwater withdrawals and low flows and in the formation of a stakeholder group to develop a water management plan that will maintain a minimum ***public rights flow*** in the river (WGCC 2009).

Coldwater streams are locally common, with many that support populations of native and nonnative trout and other coldwater organisms. The more productive among these streams are the Little Lemonweir River (Juneau and Monroe counties); White, Big Roche a Cri, Fordham, and Fairbanks creeks (Adams County); Halls, Lewis, Allen, and Levis creeks (Jackson County); and Tenmile Creek (Wood County). The mouth of Perry Creek (Jackson County) south of Black River Falls features coldwater seeps and beds of moss (*Sphagnum* spp.) that support rare insects. Segments of smaller headwaters creeks such as Carter and Little Roche a Cri creeks (Adams County) also support trout and other coldwater species. In addition, there are about 30 other streams and "stream surrogates" (agricultural ditches) of lesser habitat quality that also support trout populations to some degree. Many coldwater streams are impacted by agricultural uses and have high levels of nitrogen. Some fish from these streams contain atrazine and other tissue contaminants. In some streams, the sources of these contaminants have not yet been identified.

Morrison, White, Halls, and Crawford (Jackson County), Wedges (Clark County), and Hemlock (Wood County) creeks are examples of coolwater streams with good water quality. However, some of these streams are subject to thermal impacts from cranberry operations when warm waters from impoundments are released into the streams. Biological inventory work since the 1990s has highlighted the ecological importance of a number of additional streams, such as the East Fork of the Black River, Dickey Creek, Pigeon Creek, and Hay Creek (Jackson County) and Brandy Creek (Monroe County). These are streams with good water quality but not designated as ***Outstanding or Exceptional Resource Waters***, which support diverse populations of invertebrates, including rare species (Wisconsin DNR 2007).

The major warmwater rivers in this ecological landscape include the Wisconsin, Black, Yellow, Plover, Lemonweir, and several of the eastern tributaries of the Chippewa. The floodplains of these rivers support significant occurrences of important natural communities such as Floodplain Forest, Shrub-carr, and Emergent Marsh, and many stands also support rare species. The river corridors also provide a means by which sites within the Central Sand Plains may be connected and afford the opportunity to create or maintain connections with other regions of Wisconsin. Free-flowing stretches of headwaters streams originating in the ecological landscape's less disturbed peatlands provide habitat for rare invertebrates.

Springs

The geology of much of this ecological landscape is not favorable for the presence of an abundance of springs. Approximately 55 springs have been identified and mapped here (Macholl 2007). Most of these are in the headwaters of the upper Eau Claire River in the northwestern portion of the ecological landscape. All of these springs have a flow rate of less than 0.25 cubic feet per second and therefore are not protected by existing state groundwater laws.

Softwater springs occur here, such as those that are associated with Morrison Creek, a Black River tributary in the western part of the ecological landscape. The combination of sandy substrate and the extensive surrounding peatlands produces very soft water, and this supports an unusual assemblage of invertebrate species. Softwater seeps and spring runs are locally common features along the western edge of the ecological landscape, especially at the base of terraces bordering the Black River, and in the sandstone gorges of several of the Black River's tributaries, e.g., Morrison, Perry, Robinson, Halls, Dickey, and Valentine creeks in Jackson County. Rare plants and invertebrates are associated with some of these spring seepage complexes. Softwater springs are relatively rare in Wisconsin and occur mainly in sandy regions where the groundwater is low in mineral content.

Wetlands

The Central Sand Plains holds a significant concentration of wetlands, with the fourth largest number of wetland acres (547,000) and the second largest percentage (25.8%) of wetlands of all ecological landscapes in the state according to the Wisconsin Wetland Inventory (WWI) (Wisconsin DNR 2010c). The largest wetland acreage occurs in areas formerly occupied by the "Great Swamp of Central Wisconsin" (Martin 1916) (Figure 10.2). Significant portions of this huge former wetland are associated with the bed of extinct Glacial Lake Wisconsin.

WISCLAND (Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data) showed over 504,000 acres of wetlands here in 1992, including nearly 291,000 acres of forested wetlands (Wisconsin DNR 1993). However, WWI shows wetland acreage of 547,363 acres, covering nearly 26% of the surface area of this ecological landscape. WWI indicates approximately 261,000 forested acres and 286,000 nonforested acres (Wisconsin DNR 2010c). According to WWI, there are over 115,000 acres of "emergent/wet meadow" wetland (mainly open peatland communities: bogs, fens, and sedge meadows rather than "marshes"). Over143,000 acres are of the "shrub-scrub" wetland type. (See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for information on WISCLAND and the Wisconsin Wetlands Inventory.)

Unlike most other common wetland types in the southern half of Wisconsin, such as marshes, low prairies, shrub-carr, and bottomland hardwoods, the characteristic wetlands in this ecological landscape are peatlands, dominated by mosses, ***ericaceous shrubs***, sedges, and swamp conifers. Open Bog, Poor Fen, Muskeg, Tamarack (Poor) Swamp, and Black Spruce Swamp are all well represented here and resemble similar wetland communities that are prevalent farther north. The ecological context is quite different, though, and so are some of the uses to which these wetlands have been subjected, such as widespread cranberry production and the commercial harvest of sphagnum peat moss. Sphagnum peat moss is widespread and abundant enough in some areas to support a local industry based on the periodic harvest of the living moss. The peatlands in the Central Sand Plains are among Wisconsin's largest wetlands, especially in and around areas formerly occupied by Glacial Lake Wisconsin. Impounded peatlands are frequent, either to enhance conditions for the cranberry industry or to favor certain game species such as waterfowl. Other wetland communities occurring here include Floodplain Forest, White Pine-Red Maple Swamp, Black Spruce Swamp, Northern Sedge Meadow, Southern Sedge Meadow, Shrub-carr, Emergent Marsh, Submergent Marsh, and Coastal Plain Marsh. Wild rice (*Zizania* spp.) has been planted in a few areas (e.g., at Mirror Lake, an impoundment on lower Dell Creek in Sauk County), but few of the impounded waters in the Central Sand Plains appear well suited to sustaining populations of wild rice because of high acidity, extremely low nutrient levels, and lack of flow.

Necedah National Wildlife Refuge comprises more than 43,000 acres, and the Meadow Valley Wildlife Area partially protects another 58,327 acres for public benefit, under combined federal and state jurisdictions (federal ownership, state management). Peatland communities such as Open bog, Poor Fen, Northern Sedge Meadow, and Tamarack (Poor) Swamp are among the major wetland types found on these properties.

A portion of the ecological landscape features complex landform patterns of ancient dunes, which apparently formed when Glacial Lake Wisconsin drained and exposed great expanses of unvegetated sand. Today the dunes are forested, mostly with "scrub" oak (*Quercus velutina* and *Q. ellipsoidalis*) and jack pine (*Pinus banksiana*); the hollows between them support wetlands, usually Poor Fen, sedge meadow, and shrub swamp.

In some areas, low gradient stretches of large rivers such as the Wisconsin, Black, and Yellow have developed broad floodplains. These floodplains support extensive Floodplain Forest (bottomland hardwoods) and lesser amounts of Shrub-carr, Southern and Northern Sedge Meadows, and Emergent Marsh.

Wetlands occupied 26% of the Central Sand Plains Ecological Landscape at the time of the Public Land Survey in Wisconsin, conducted between 1832 and 1866 by the federal General Land Office (Finley 1976). Marshes, sedge meadows, wet prairie, and lowland shrubs made up 9% of the ecological landscape by area, and swamp conifers, primarily tamarack, comprised another 17%. In addition to lands identified specifically as "wetland," the water table is very near the surface over extensive portions of this ecological landscape, limiting some land uses and creating seasonally wet conditions at some locations.

Early in the 20th century, there were many attempts to drain the wetlands of Wisconsin's Central Sands region. The high water table, low soil fertility, and growing season frosts made agriculture in this area generally unsuccessful, especially west of the Wisconsin River. The agricultural focus there has shifted to emphasize cranberry production, where the intent is not to get rid of the water but rather to control it to facilitate commercial

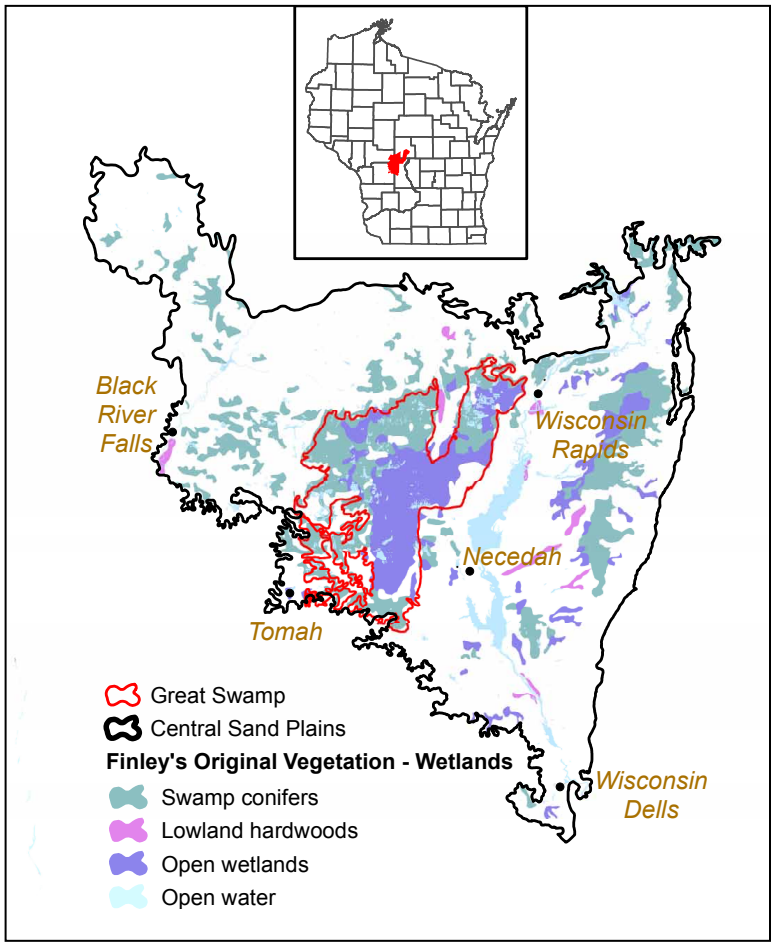


Figure 10.2. *The Great Swamp of Central Wisconsin. The most extensive area of contiguous wetlands in Wisconsin occupied poorly drained portions of the present-day Central Sand Plains Ecological Landscape. Much of this swampy area was within the bed of now extinct Glacial Lake Wisconsin.*

growing and harvesting of cranberries. The cranberry farm impoundments are used as a source of water to supply sprinkler systems, which are used to prevent damage to the cranberry plants when temperatures drop below freezing during the summer. Over 8,500 acres of wetlands in the Central Sand Plains have been converted directly to cranberry beds (Wisconsin DNR 2007), with many additional acres affected by the construction of impoundments for the purpose of water storage (it is uncertain whether all of these acres were all wetlands prior to impoundment construction).

In the drained lands to the east of the Yellow and Wisconsin rivers (much of it formerly supporting conifer swamp, bog, sedge meadow, fen, or xeric upland forests of pine and scrub oak), intensive agriculture is now practiced, and much of this is dependent on center pivot irrigation. Crops include potatoes, corn, soybeans, vegetables, and various small grains. The land here that is not under cultivation comprises one of the state's largest grassland complexes, though these grasslands are dominated mostly by nonnative plant species.

Large, hydrologically intact open peatland is dominated by sedges and sphagnum mosses. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

This large peatland complex has been almost entirely converted to commercial cranberry production. Northeastern Monroe County. Photo by Eric Epstein, Wisconsin DNR.

Many grassland birds, including a number of Species of Greatest Conservation Need, find suitable nesting habitat in these "surrogate (prairie) grasslands." See the "Fauna" section below for details. Some wetland areas that were not irremediably converted to agricultural uses have been partially restored and now constitute the core conservation areas of some of the extensive public lands, especially in the western part of the ecological landscape.

The commercial harvest of sphagnum mosses from both public and private lands has taken place in the western part of the ecological landscape since the late 19th century (Esposito 2000). See the "Land Use Impacts" section of this chapter for further information.

Several rare wetland communities of limited state distribution are well represented in the Central Sand Plains Ecological Landscape, including White Pine-Red Maple Swamp and Coastal Plain Marsh. Quincy Bluff State Natural Area contains examples of these and other wetlands, including Poor Fen, sedge meadow, tamarack swamp, and Ephemeral Pond; these wetlands support rare plants, insects, and birds. More detailed descriptive information on the individual wetland communities may be found in Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book. Additional information on wetlands and their associated biota may be found in the sections on "Flora" and "Fauna," below.

Water Quality

The rivers, impoundments, and lakes of this ecological landscape exhibit a wide range of surface water quality conditions, from excellent to poor (see Appendix 10.A). A few streams are classified as ***Outstanding or Exceptional Resource Waters***, while others are degraded enough to require classification as 303(d) Impaired Waters. Groundwater quality also varies widely from watershed to watershed, and generally reflects the land use impacts in areas with permeable soils and shallow depth to groundwater.

The huge Petenwell Flowage on the Wisconsin River now experiences significant summer algae blooms, the result of phosphorus and nitrates entering the river from nonpoint sources. This is also occurring in other impoundments in the Central Wisconsin River basin, including Castle Rock Flowage just downstream from Petenwell.

Halls Creek and Little Roche a Cri Creek watersheds, along with the North Fork and the South Fork of the Eau Claire River watersheds, have the cleanest water among all watersheds here. They are protected by a combination of extensive forest cover and land uses that release relatively few nonpoint pollutants. Most other watersheds are impacted to varying degrees by sediment and nutrient inputs via ditches, eroding streambanks, removal of windbreaks along agricultural fields, and the use of pesticides and nitrogen fertilizers on croplands and cranberry marshes (Schreiber 1988). Impoundments are often eutrophic and exhibit excessive weed and algae growth.

Outstanding Resource Waters (ORW) or Exceptional Resource Waters (ERW) are surface waters that have good water quality, support valuable fisheries and wildlife habitat, provide outstanding recreational opportunities, and are not significantly impacted by human activities. Waters with ORW or ERW status warrant additional protection from the effects of pollution. Both designations have regulatory restrictions, with ORWs being the most restricted. These designations are intended to meet federal Clean Water Act obligations and prevent any lowering of water quality or degrading of aquatic habitats in these waters. They are also used to guide land use changes and human activities near these waters.

There is only one ORW stream in this ecological landscape—Big Roche a Cri Creek in Adams County (above Highway W). This makes protecting the numerous ERW streams a high priority. Exceptional Resource Waters in the Wisconsin River drainage include all or portions of Fairbanks and Gulch creeks (Adams County). Some of the ERW streams in the Black River watershed include Darrow Creek (Eau Claire County), and Allen, Beltz, Cisna, Snow, Valentine, and Wyman creeks (Jackson County). There are also numerous ERW streams in the Dell Creek, Duck Creek, and Lower Lemonweir watersheds, including Campbell, Corning, and Plainville creeks (Adams County); Dell Creek (Sauk County); Duck Creek (Portage County); Hulburt Creek (Sauk County), and Gilmore, Brewer, and One-Mile creeks (Monroe and Juneau counties). A complete list of ORW and ERW in this ecological landscape can be found on the Wisconsin DNR's website (Wisconsin DNR 2012b).

Waters designated as 303(d) impaired under the Clean Water Act by the U.S. Environmental Protection Agency (EPA) exhibit various water quality problems including PCBs in fish, sediments contaminated with industrial metals, mercury from atmospheric deposition, bacteria from farm and urban runoff, and habitat degradation. Since the 303(d) designation is based on the numeric water quality criteria included in chs. NR 102–105, Wisconsin Administrative Code, Wisconsin DNR technical documents, narrative standards, and federal guidance, a waterbody could be listed as a 303(d) water as well as an ORW or ERW (see "Aquatic Communities" in Chapter 2, "Assessment of Current Conditions," for more information on water quality standards). These designations are not mutually exclusive. A plan is required by the EPA on how 303(d) designated waters will be improved by the Wisconsin DNR. This designation is used as the basis for obtaining federal funding, planning aquatic management work, and meeting federal water quality regulations.

The upper Yellow River watershed had been selected as a ***Priority Watershed*** and had all of its scheduled restoration and protection projects completed as of December 2005 (Wisconsin DNR 2007). Several streams in the Crossman Creek and Little Baraboo River watershed (LW23) have been monitored for pollutants because they are already on the 303(d) list of impaired waters or have the potential to be included. The complete list of 303(d) impaired waters and criteria can be viewed at the Wisconsin DNR's impaired waters web page (Wisconsin DNR 2012c).

Surface water and groundwater susceptibility to nonpoint pollution have been assessed in the watersheds within the Central Sand Plains by the Bureau of Watershed Management. Most watersheds in this ecological landscape are susceptible to some degree to both surface and groundwater contamination from nonpoint sources. Groundwater susceptibility to nonpoint pollution and contamination is most often related to a combination of land use, type of bedrock, depth to bedrock, depth to water table, soil characteristics, and characteristics of surficial deposits. Groundwater susceptibility rankings by the Wisconsin DNR also factor in groundwater contaminant sampling, when such information is available.

Nineteen of the 30 watersheds in this ecological landscape are rated as highly vulnerable to potential negative impacts from nonpoint source pollution because they are vulnerable to groundwater pollution. This indicates that groundwater, as well as many streams and rivers in the Central Sand Plains Ecological Landscape that may not presently be degraded, are potentially threatened by point or nonpoint source pollution (WGNHS and Wisconsin DNR 1989).

These watersheds contain waterbodies such as Big Roche a Cri Creek (Adams County), the lower Yellow River (Juneau and Wood counties), 49 miles of the Wisconsin River (Adams, Columbia, Juneau, Portage, Sauk, and Wood counties), and 4.3 miles of Springbrook and Dell creeks (Sauk County). Specific groundwater contamination or other groundwater problems have been documented from sampling within Fourteen Mile Creek (Adams County) (nitrates and iron); Mill Creek (Monroe County) (coliform bacteria); and Little Eau Claire River, Narrows Creek and the Baraboo River, Duck and Plainville Creeks, Dell Creek, and Lower Lemonweir River watersheds (nitrate and pesticides) (Wisconsin DNR 2002a, Wisconsin DNR 2012c). Pollutants come from point source discharges, nutrient and sediment runoff from agriculture, construction site erosion, and residential development. Thermal impacts, as well as nutrients and pesticides, have also been noted from cranberry operations (Schreiber 1993).

Biotic Environment

Vegetation and Land Cover

Historical Vegetation

Several sources were used to characterize the historical vegetation of the Central Sand Plains, relying most heavily on data from the General Land Office's Public Land Survey (PLS), (Schulte and Mladenoff 2001). PLS data are useful for providing estimates of forest composition and tree species dominance for large areas (Manies and Mladenoff 2000). Finley's (1976) map of historical land cover based on his interpretation of PLS data was also consulted. Additional inferences about vegetative cover were sometimes drawn

from information on land capability, climate, disturbance regimes, the activities of native peoples, and from various descriptive narratives. More information about these data sources is available in Appendix C, "Data Sources used in the Book" in Part 3 ("Supporting Materials").

According to Finley's map and data interpretation, in the mid-1800s the Central Sand Plains Ecological Landscape contained a mixture of dry vegetation types (forest, savanna, and prairie) combined with wetland types (forested and nonforested). Only 6% (135,000 out of 2,189,000 acres) of the ecological landscape was covered by northern or central hardwoods (Figure 10.3). Jack pine, scrub oak, and barrens covered 26% of the area, with oak forest the next most extensive cover type at 20%. PLS information has been converted to a database format, and ***relative importance values (RIV)*** for tree species were calculated based on the average of tree species density and basal area (He et al. 2000). This analysis indicates that eastern white pine (*Pinus strobus*) (24% of the RIV), jack pine (13% of the RIV) and black oak (*Quercus velutina*) (12% of the RIV) had the highest RIVs of all tree species found in this ecological landscape (49% total). The other tree species with RIVs higher than 5% were red pine (*Pinus resinosa*) (9% of the RIV), tamarack (*Larix laricina*) (8% of the RIV), white oak (*Quercus alba*) (8% of the RIV), and bur oak (*Quercus macrocarpa*) (7% of the RIV). See the map entitled "Vegetation of the Central Sand Plains Ecological Landscape in the Mid-1800s" in Appendix 10.K at the end of this chapter. Also see Finley's map of Wisconsin's presettlement vegetation in Appendix G, "Statewide Maps," in Part 3 of the book ("Supporting Materials").

Current Vegetation

There are several data sets available to help assess current vegetation on a broad scale in Wisconsin. Each was developed for different purposes and has its own strengths and limitations in describing vegetation. For the most part, the Wisconsin Wetlands Inventory (WWI), WISCLAND, the U.S. Forest Service's Forest Inventory and Analysis (FIA), and the National Land Cover Database (NLCD) were used. Results among these data sets often differ because they are the products of different methodologies for classifying land cover, and each data set was compiled based on sampling or imagery collected in different years, sometimes at different seasons, for different purposes, and at different scales. In general, information was cited from the data sets deemed most appropriate for the specific factor being discussed. Information on data source methodologies, strengths, and limitations is provided in Appendix C, "Data Sources used in the Book" in Part 3 ("Supporting Materials"). WISCLAND land use/land cover data (Wisconsin DNR 1993) classifies general land cover attributes and can be useful in characterizing large-scale land use features. It is based on satellite imagery from 1992, so it does not represent present-day information. We use it here to offer a general view of land use and land cover in this ecological landscape.

The Central Sand Plains was approximately 2,189,000 acres in size, of which approximately 52% was forested in 1992 (Figure 10.4) (Wisconsin DNR 1993). This is the highest percentage of forested land cover of all of the ecological landscapes south of the Tension Zone. WISCLAND land use/land cover data also indicates that 16% of the ecological landscape was in agricultural use at the time, which is the lowest percentage of agricultural use of all of the ecological landscapes south of the Tension Zone.

The Wisconsin Wetland Inventory (Wisconsin DNR 2010c) identifies wetlands by interpreting aerial photographs, offering a more detailed assessment than the WISCLAND data, which comes from the interpretation of satellite imagery. According to the Wisconsin Wetland Inventory, wetlands occupy a relatively large portion of the Central Sand Plains, comprising 25%, or approximately 547,000 acres of this ecological landscape's vegetation. Forested wetlands make up over 260,000 acres of the ecological landscape, making these the most abundant wetland types in the Central Sand Plains. Shrub/scrub wetlands occur across approximately 144,000 acres. Wet meadows (which include marshes, sedge meadows, and acid fens) occupy approximately 116,000 acres.

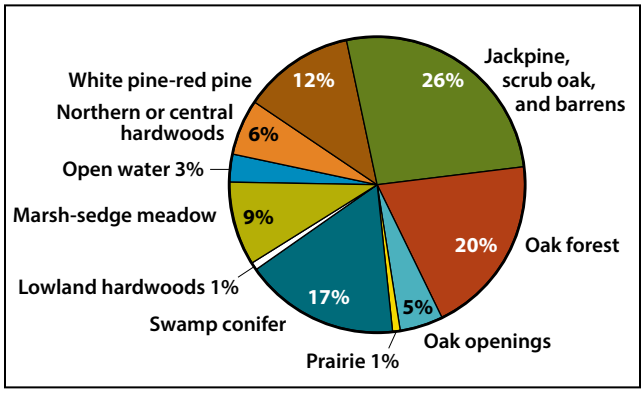


Figure 10.3. *Vegetation of the Central Sand Plains Ecological Landscape during the mid-1800s as interpreted by Finley (1976) from Public Land Survey information.*

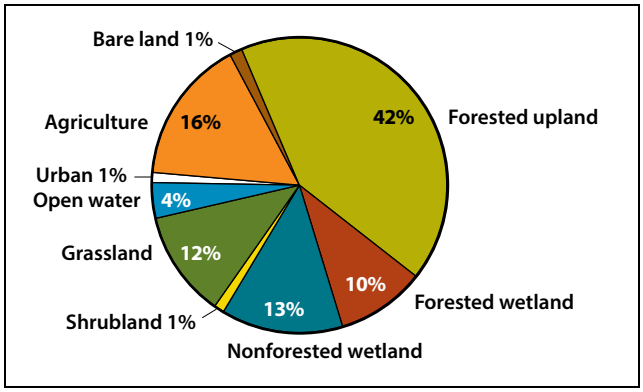


Figure 10.4. *WISCLAND land use/land cover data showing categories of land use classified from 1992 LANDSAT satellite imagery for the Central Sand Plains Ecological Landscape (Wisconsin DNR 1993).*

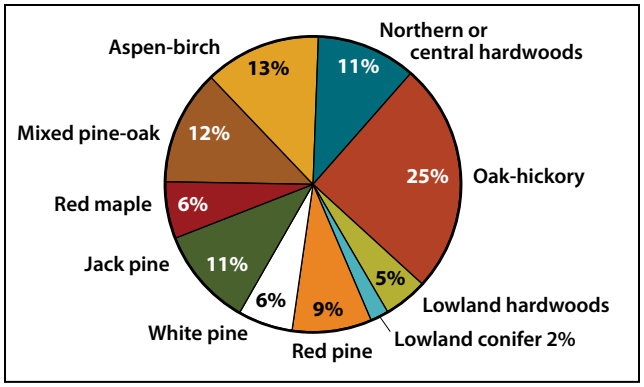


Figure 10.5. *Forest Inventory and Analysis data (USFS 2004) showing forest type as a percentage of forested land area (greater than 17% crown cover) for the Central Sand Plains Ecological Landscape. See Appendix C, "Data Sources Used in the Book," in Part 3 for more information about the FIA data.*

Additional information on wetlands and wetland flora may be found in the "Natural Communities" and "Flora" sections of this chapter and in Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book.

Forest Inventory and Analysis (FIA) data is a U.S. Forest Service program that compiles point samples of forested lands to assess the timber resources of the country. It contains more information on forest types and species compositions that can be generalized across the ecological landscapes and offers more specific information about forested lands than WISCLAND. Because FIA data are derived from on-the-ground sampling as opposed to interpretations of remote satellite imagery, the numbers may offer a different interpretation of forest cover than WISCLAND. According to FIA data summarized in 2004, approximately 43% of land area in the Central Sand Plains is nonforested, and about 57% is forested (USFS 2004). The predominant forest cover type group is oak-hickory (25% of the forested area), followed by aspen-birch (13%), mixed pine-oak (13%), northern or central hardwoods (11%), and jack pine (11%) (Figure 10.5). All other forest types occupy less than 10% of the forested area.

Changes in Vegetation Over Time

The purpose of examining historical conditions is to identify ecosystem factors that formerly sustained species and communities that are now altered in number, size, or extent or that have been changed functionally (for example, by constructing dams or suppressing fires). Although our data are limited to specific snapshots in time, they provide valuable insights into Wisconsin's history and ecological capabilities. Maintaining or restoring some lands to more closely resemble historical systems and including some structural or compositional components of the historical landscape can help conserve important elements of biological diversity. We do not mean to imply that entire ecological landscapes should be restored to historical conditions, as this is not possible nor desirable within the context of providing for human needs and desires. Information on the methodology, strengths, and limitations of the vegetation change data is provided in Appendix C, "Data Sources Used in the Book," in Part 3 ("Supporting Materials").

Current forest vegetation (based on FIA) is primarily oak species (34% of RIV), red maple (*Acer rubrum*) (15%), red pine (13%), aspen-birch (12%), and eastern white pine (12%) (Figure 10.6). Aspen (*Populus* spp.) has increased as compared with historical conditions from 5% to 12% of RIV, while red maple has increased from 1.5% to 15%. Eastern white pine has decreased (from 24% of RIV to 12%) as has tamarack (from 8% to less than 1% of RIV). Many stands without a shade-tolerant forest understory have a developing eastern white pine understory within this area and in the Central Sand Hills Ecological Landscape. If high deer densities do not limit stand development, many oak stands will succeed to mixed forests of oaks and eastern white pine.

Some of the major changes that occurred between the PLS surveys of the mid-1800s and the collection and analysis of FIA data in 2004 were due to the policies of fire suppression, which were widely implemented after the 1920s and 1930s. This has led to severe declines in some of the fire-adapted and fire-dependent vegetation, include Pine Barrens, Oak Barrens, and jack pine forest. In aggregate, these types made up over 25% of the vegetation at the time of the PLS. Barrens vegetation has no direct analog in the FIA data.

According to FIA data, much of the red pine growing here now has been planted. Eastern white pine RIV decreases were due to a combination of intensive logging targeting that species and postharvest fires, which would have eliminated small eastern white pine (seedlings, saplings, small trees) and much of the remaining eastern white pine seed source. In parts of the Central Sand Plains, such as the Black River State Forest, eastern white pine is now a common subcanopy species, often under oaks or aspens, and sometimes even under planted red pine. This can be problematic in areas that formerly supported barrens vegetation or in forests that were composed of light-demanding tree species such as jack pine or scrub oak. In such cases, the increase in eastern white pine has as much to do with fire suppression policies as it does with site suitability. The tremendous increase in red maple RIV recently is likewise a reflection of widespread fire suppression more than any other factor.

In areas that remain heavily forested, there have been some shifts in which groups of tree species are now dominant. For example, in areas that historically supported large amounts of eastern white (and some natural red) pine (e.g., east of the present location of the Black River State Forest in Jackson County and along the East Fork of the Black River), red pine plantations and aspen now make up much of the forest cover. This had been the location of a significant and extensive historical pinery.

The globally rare barrens ecosystems, and the many rare plants and animals dependent on them, have generally been

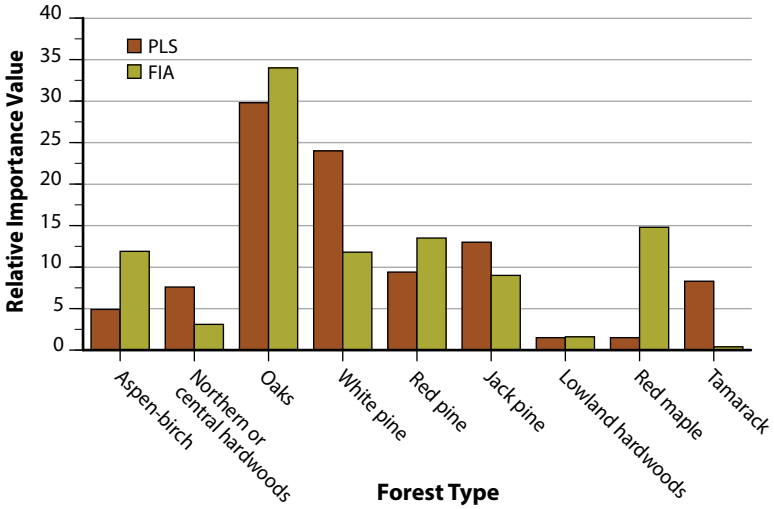


Figure 10.6. *Comparison of tree species' relative importance value (average of relative dominance and relative density) for the Central Sand Plains Ecological Landscape during the mid-1800s, when General Land Office Public Land Survey (PLS) data were collected, with 2004 estimates from Forest Inventory and Analysis (FIA) data (USFS 2004). Each bar represents the proportion of that forest type in the data set (totals equal 100). Trees of less than 6-inch diameter were excluded from the FIA data set to make it more comparable with PLS data. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the PLS and FIA data.*

reduced to small, often degraded remnants. The most extensive areas of historical barrens are now managed intensively for forest products in Adams County and parts of Jackson and Juneau counties. The recently approved master plan for the Black River State Forest seeks to partially address this via the designation of a "jack pine management area." Barrens restoration has been a major management goal of the U.S. Fish and Wildlife Service at Necedah National Wildlife Refuge.

Changes in Nonforested Habitats. The impacts to wetlands over time cannot be easily quantified, but in parts of Adams and Juneau counties, ditching of the peatlands caused the water table to drop as much as 12 feet (Bordner et al. 1934, Goc 1990). Following the abandonment of attempts to farm these lands, and their subsequent reversion to public ownership, some wetlands were "restored" by plugging ditches and constructing dike systems.

The loss of tamarack may have been due to exploitation, hydrologic disruption, and fires related to reckless timber harvests as the water table dropped, but outbreaks of insect pests such as the larch sawfly (*Pristiphora erichsonii*) and eastern larch beetle (*Dendroctonus simplex*) may also have played major roles in tamarack decline here, as they did in many parts of northern and southeastern Wisconsin where tamarack has also experienced great declines.

Wetlands are still abundant in the Central Sand Plains and include types that are unusual or rare in this region and that are also rare from a statewide perspective. Hydrologic disruption has been pervasive, and species such as tamarack are far less important now than they once were. Dams have impacted most of the rivers and larger streams, with the ultimate impacts uncertain. Rare fire-dependent ecosystems such as Oak and Pine Barrens occur as scattered remnants, and on some public and private lands, barrens restoration at multiple scales is a priority management goal. Numerous rare plants and animals are dependent on these plant communities. Forests remain abundant in the western part of the Central Sand Plains, but there have been shifts in dominance, patch size and shape; in size and age class structures; and in the locations of some of the largest areas of forest. Some areas that formerly supported open vegetation are now heavily forested; areas that were heavily forested have been cleared and converted to other cover types and uses.

Natural Communities

This section summarizes the abundance and importance of major ***physiognomic*** (structural) ***natural community groups*** in this ecological landscape. Some of the exceptional opportunities, needs, and actions associated with these groups, or with some of the individual natural communities, are discussed briefly. For details on the composition, structure, and distribution of the specific natural communities of the Central Sand Plains Ecological Landscape, see Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book. Information on invasive species can be found in the "Natural and Human Disturbances" section of this chapter.

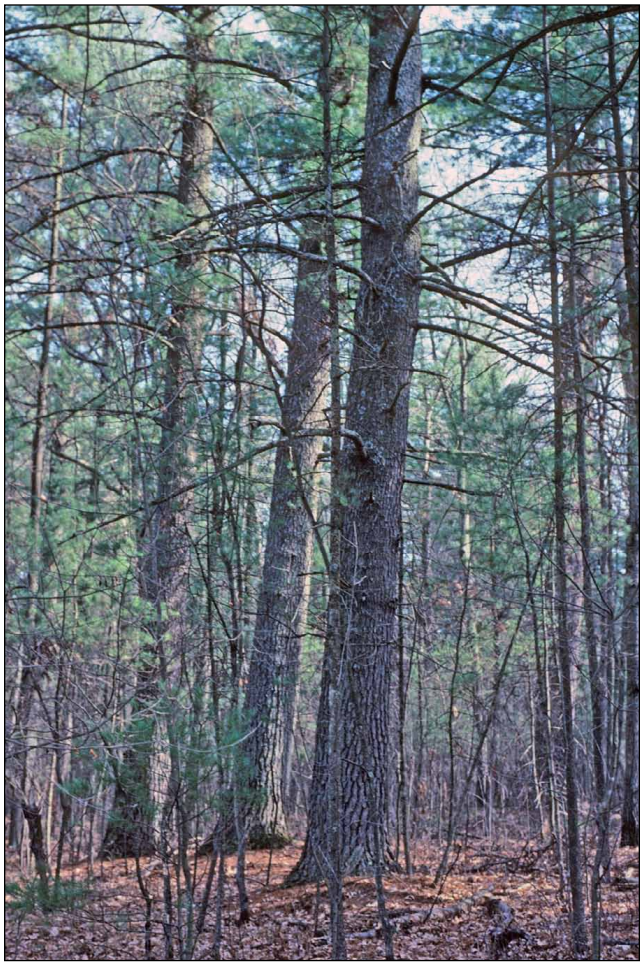
Forests. The most extensive upland forests occur on sandy or rocky substrates and are generally dry or, more rarely, dry-mesic. Dominants include oaks, pines, and aspens. Nutrient-rich mesic hardwood forests are rare here but have been found on some of the higher terraces along the Black River and occasionally on morainal deposits in the north-central portion of the ecological landscape. Northern Mesic Forest ("hemlock hardwoods") is locally distributed, occurring as relicts in a few cold sandstone gorges in the southern part of the ecological landscape and on morainal deposits near the Wisconsin River north of Wisconsin Rapids.

Not all forests in central Wisconsin are a good fit for either the "Southern" or "Northern" Dry Forests described by Curtis (1959). Proximity to the climatic Tension Zone is one of the factors that allows floristic elements of the north and south to co-occur here, and so a provisional "Central Sands Pine-Oak Forest" community has been described and used to classify some of the mixed xeric pine-oak forests of central Wisconsin.

Forested lowlands are represented by linear corridors of Floodplain Forest—composed almost entirely of deciduous species such as silver maple (*Acer saccharinum*), river birch (*Betula*

Floodplain Forest of silver maple, river birch, and green ash along the Black River. Black River State Forest, Jackson County. Photo by Emmet Judziewicz.

Complex mosaic of dry and wet-mesic pine-oak-maple forests and open peatlands. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.



Xeric forest of mature eastern white pine, red pine, white oak, and black oak. Overmeyer Hills, Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

nigra), and green ash (*Fraxinus pennsylvanica*)— along the major rivers. These are best developed within the floodplains of the Black, Yellow, and Lemonweir rivers. Large stands still occur along some stretches of the Wisconsin River, but the large dams that created the Castle Rock and Petenwell flowages also inundated large acreages of Floodplain Forest. Swamp conifers occur in areas of poorly drained sandy outwash and in the undrained remnants of Glacial Lake Wisconsin as Northern Wet Forest (both the very acid Black Spruce Swamp and the somewhat more ***minerotrophic*** Tamarack Swamp occur here). A wet-mesic forest community dominated by eastern white pine and red maple (White Pine-Red Maple Swamp) is especially important here because it supports numerous rare or otherwise notable species and has been documented in very few ecological landscapes other than the Central Sand Plains.

Savannas. Barrens vegetation was historically widespread on droughty sands derived from outwash, ***glaciolacustrine deposits***, and erosional processes. Many decades of fire suppression have greatly reduced or degraded the extent of the more open barrens, and without restoration at a substantial scale, the barrens communities are unlikely to maintain the large number of associated native plants, invertebrates, herptiles, birds, and mammals that thrive in this habitat now. Some of the more area-sensitive barrens animals are barely persisting here now and do so by using open wetlands (especially wet meadows and fens) and abandoned agricultural lands to help meet their habitat needs (e.g., Sharp-tailed Grouse [*Tympanuchus phasianellus*]). Many barrens associates occur in isolated, degraded remnants that will require active management to increase habitat size, restore composition, reduce the amount of unwanted woody vegetation, and periodically connect with other patches of barrens habitat that support otherwise isolated species populations.

Until recently, most of the managed "barrens" in this ecological landscape exhibited "brush prairie" structure, with the

Pine Barrens community with scattered small jack pines and a rich sand prairie understory. Bauer-Brockway Barrens State Natural Area, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Pine Barrens understory at Coon Fork Barrens State Natural Area in the Eau Claire County Forest includes wild lupine (Lupinus perennis)*, cylindrical blazing-star* (Liatris cylindracea)*, lance-leaved loosestrife* (Lysimachia lanceolata)*, and prairie grasses. Eau Claire County. Photo by Eric Epstein, Wisconsin DNR.*

woody component represented mostly by oak grubs (usually *Quercus velutina*, *Q. ellipsoidalis*, or *Q. macrocarpa*) reduced in stature to heights of no more than several meters. Following Euro-American settlement, barrens vegetation declined quickly and dramatically because of fire suppression, successional processes, attempts to practice agriculture, and more recently, deliberate ***type conversions***. The latter often followed infestations of jack pine budworm (*Choristoneura pinus*), which killed or damaged many jack pine trees. Red pine has been the species most often planted on sites formerly dominated by jack pine and/or scrub oak. Currently the process of stand conversion from barrens cover to plantation monotypes may include mechanical clearing, furrowing, scalping, and herbicide treatment, making restoration efforts even more acute, challenging, and expensive.

Shrub Communities. Alder Thicket is the most common wet shrub community in the Central Sand Plains Ecological Landscape, where it occurs along streams (especially west of the Yellow River) and on the margins of some of the large peatlands. Shrub-carr communities, composed mostly of dogwoods (*Cornus* spp.) and willows (*Salix* spp.), are present but more locally distributed.

Not a natural community per se, heavily cut upland forests of oak or aspen go through a relatively brief "shrub" (sapling) phase, creating habitats that can be important to several wildlife species of conservation concern (see Appendix 10.E, "Species of Greatest Conservation Need Found in the Central Sand Plains Ecological Landscape," at the end of this chapter). Some of the managed barrens here are maintained in this shrub (or "grub" stage) deliberately via the use of prescribed fire, cutting, and herbicide application. Such habitats must be planned carefully, with consideration for the ecological potential of the surrounding landscape, in order to maintain or develop the range of habitats and patch sizes needed to provide for all species. For example, habitats for species requiring older forests with large trees, high crown closure, and distributed in large patches are limited here, but they do exist along the major rivers, in some of the larger forested peatlands, and on some upland sites in the western parts of the ecological landscape. Large areas of open, or semi-open, lands are also needed. The Central Sand Plains Ecological Landscape, unlike most of southern Wisconsin, could accommodate the full range of habitat developmental stages and patch sizes needed to support almost all of the species native to this ecological landscape, including habitat specialists and those that are area-sensitive.

Herbaceous Communities. The herb-dominated communities of the Central Sand Plains are mostly wetlands. The open acid peatlands (especially Open Bog, Poor Fen, and Muskeg communities) and the sedge meadows (both southern tussock meadows and northern "wiregrass" types occur in this ecological landscape) are of special significance because of their size, the species they support, and, in some cases, their context. The composition of some of the open acid peatlands in central Wisconsin differs somewhat from hydrologically and structurally similar peatlands in northern Wisconsin, consistently enough that they are currently described by the Wisconsin DNR's Natural Heritage Inventory as the Central Poor Fen community (see Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin"). These differences include the apparent absence or greatly reduced status of some bog shrubs that are common or dominant in the north; the abundance of steeplebush (*Spiraea tomentosa*); the presence of plants of generally more southern distribution that are absent or uncommon in northern peatlands, such as Kalm's St. John's wort (*Hypericum kalmianum*); and the sporadic but widespread occurrence in this ecological landscape of plants belonging to a group termed collectively as "Atlantic Coastal Plain disjuncts" (see the "Flora" section of this chapter for additional information on this group).

It's possible that the severe fires that burned through the peatlands of the Central Sand Plains Ecological Landscape in the past had a significant influence on peatland substrates as

This extensive open peatland complex of poor fen and northern sedge meadow is on the Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

well as on community structure and composition, but more detailed studies are needed to clarify this. Many peatlands in the Central Sand Plains were badly damaged by ditching and severe drops in the water table, subsequent fires, and even attempts to grow crops in the early part of the 20th century (Goc 1990). These damaged wetlands formed the cores that led to the creation of some of the large public lands now found in this ecological landscape, especially west of the Yellow River.

Native prairie is limited here, and most "prairie" remnants are associated with former oak or pine barrens vegetation from which tree or "grub" cover had been eliminated or severely suppressed (e.g., by periodic mowing or herbicide use in rights-of way) in historical times. Sand Prairie occurs on treeless outwash plains, and Dry Prairie occupies steep south- or west-facing slopes of some of the striking sandstone bluffs, buttes, and mounds that punctuate parts of the Central Sand Plains. Wet Prairie was probably always rare and now persists only as small patches on the margins of sedge meadow, Open Bog, or Poor Fen communities. Sparsely vegetated Sand Prairies or barrens impacted by past agricultural use or other severe disturbances sometimes feature "***blowouts***," which may support rare specialists (including rare vascular and nonvascular plants and rare invertebrates). Such sites, however, may become quickly overrun with highly invasive weeds such as cypress spurge (*Euphorbia cyparissias*), leafy spurge (*Euphorbia esula*), and spotted knapweed (*Centaurea biebersteinii*).

Though not a "natural community," the extensive grasslands that now vegetate much of the area east of the Wisconsin River known as the Buena Vista and Leola "marshes" are ecologically significant. These lands formerly supported a mosaic of forest and wetland communities that was drained and cleared for agricultural use in the late 19th and early 20th centuries. Now dominated by nonnative grasses and agricultural crops, these ***surrogate grasslands*** provide breeding and wintering habitat for many grassland birds that can no longer find suitable habitat in severely fragmented patches of native grasslands. Initially established to conserve dwindling populations of the Greater Prairie-Chicken, the Central Wisconsin Grasslands Conservation Area is one of Wisconsin's most critical sites for the conservation of grassland birds (Sample and Mossman 1997). These grasslands also support invertebrates and mammals of conservation concern.

Miscellaneous Communities. Exposures of Cambrian sandstone bedrock are prominent features in parts of the Central Sand Plains Ecological Landscape, where they form buttes, mesas, pinnacles, gorges, and series of cliffs. The physical aspect presented by such features is unique and unlike any other landscape in the upper Midwest (Martin 1916). Dry Cliffs and, less commonly, Moist Cliffs associated with these outcroppings host highly specialized plants and animals, including rare species.

Forest Habitat Types

The Central Sand Plains Ecological Landscape is dominated by three forest habitat type groups: dry, mesic to wet-mesic, and wet-mesic to wet. (Table 10.1). Dry-mesic and mesic sites are uncommon. Dry sites are typically associated with sandy soils that are excessively to somewhat excessively drained and nutrient poor to medium. Currently, oaks (pin, black, red, white) and pines (jack, red, white) are the dominant trees; aspen and red maple also are common. In the absence of severe disturbance, potential late-successional dominants are eastern white pine and red maple, accompanied by white oak and northern red oak (*Quercus rubra*).

Mesic to wet-mesic sites are typically associated with sandy soils that are somewhat poorly drained and nutrient poor to medium. Currently, the most common overstory dominants are aspen, red maple, eastern white pine, and northern pin and black oaks; common associates and occasional dominants include jack pine, red pine, northern red oak, white oak, and white birch (*Betula papyrifera*). In the absence of severe disturbance, potential late-successional dominants are eastern white pine and red maple.

Wet-mesic to wet forested lowlands typically occur on poorly drained, nutrient-poor-to-medium peat and muck soils. Most stands are dominated by swamp conifers but may include jack pine, eastern white pine, red maple, white birch, and aspen. A few sites with richer muck or mineral soils do occur and may be dominated by either swamp conifers or hardwoods. For more information regarding the habitat type classifications, see Appendix 10.B, "Forest Habitat Types in the Central Sand Plains Ecological Landscape," at the end of this chapter.

Flora

Fifty-five vascular plant species inhabiting the Central Sand Plains are included on the Wisconsin Natural Heritage Working List (Wisconsin DNR 2009). Six of these species are listed as Wisconsin Endangered, eight are listed as Wisconsin Threatened, and 41 are listed as Wisconsin Special Concern.

Table 10.1. *Forest habitat type groups and forest habitat types[a] of the Central Sand Plains Ecological Landscape (CSP EL).*

Southern forest habitat type groups common within the CSP EL[b]	Southern forest habitat types common within the CSP EL[b]	Southern forest habitat types minor within the CSP EL[b]
Dry (D)	PEu PVG PVGy PVHa	PVCr
Mesic to wet-mesic (M-WM)	PVRh	
Wet-mesic to wet (WM-W)	Forest lowland (habitat types not defined)	
Southern forest habitat type groups minor within the CSP EL		
Dry-mesic (DM)		ArDe
Mesic (M)		

Source: Kotar and Burger (1996).
[a]Forest habitat types are explained in Appendix 10.B ("Forest Habitat Types in the Central Sand Plains Ecological Landscape") at the end of this chapter.
[b]Groups listed in order from most to least common:
Common occurrence is an estimated 10–50% of forested land area.
Minor occurrence is an estimated 1–9% of forested land area.
Present – other habitat types can occur locally, but each represents < 1% of the forested land area of the ecological landscape.

No federally listed plants are known from the Central Sand Plains as of November 2009.

Of these 55 rare plant species, seven have been recorded in no other ecological landscape. These include early anemone (*Anemone multifida* var. *hudsoniana*), long-leaved aster (*Aster longifolius*), clustered sedge (*Carex cumulata*), straw sedge (*C. straminea*), catfoot (*Gnaphalium helleri* var. *micradenium*), northern prostrate clubmoss (*Lycopodiella margueritae*), and reticulated nutrush (*Scleria reticularis*).

For an additional 14 species, 50–99% of the known Wisconsin populations occur in the Central Sand Plains. Notable species from this group include twining screwstem (*Bartonia paniculata*); yellow screwstem (*B. virginica*); long sedge (*Carex folliculata*); cliff cudweed (*Gnaphalium obtusifolium* var. *saxicola*), which is endemic to Wisconsin; grassleaf rush (*Juncus marginatus*); crossleaf milkwort (*Polygala cruciata*); meadow beauty (*Rhexia virginica*); lapland azalea (*Rhododendron lapponicum*); bog fern (*Thelypteris simulata*); and sand violet (*Viola fimbriatula*).

Globally rare plants include sweet-scented Indian-plantain (*Cacalia suaveolens*), cliff cudweed, northern prostrate clubmoss, bog bluegrass (*Poa paludigena*), and shadowy goldenrod (*Solidago sciaphila*). For additional information, see Appendix 10.C, which has a complete listing of the rare plants documented from this ecological landscape for which records have been submitted to the Wisconsin Natural Heritage Inventory within the past thirty years. This table includes a comparison of the number of statewide populations with the number of populations found in the Central Sand Plains and gives state and global ranks and legal status of each species.

The Central Sand Plains straddles the Tension Zone. The flora is a partial reflection of this geographic position because it contains a diverse mixture of elements from both "southern" and "northern" ecosystems (this is also true of fauna). This ecological landscape also contains several habitats that are highly unusual because of their rarity, restricted distribution, or some intrinsic localized factor, such as post-Pleistocene history, soils, or hydrology.

The "southern" plants are species occurring mostly south of the Tension Zone, which are generally affiliated with prairie, savanna, and dry hardwood forest habitats. Plants associated with sand prairie, oak barrens, and pine barrens communities are particularly well represented in the Central Sand Plains and include many species that are now rare, uncommon, or declining. Both pine barrens and oak barrens habitats were historically abundant in Wisconsin, covering millions of acres at the onset of Euro-American settlement. Since then, agricultural and forestry practices and the widespread implementation of fire suppression policies, have led to tremendous declines in the total acreage of all barrens and sand prairie vegetation. Increases in woody cover, stem densities, and the heavy shading produced by trees and shrubs have occurred, leading to the loss of suitable habitat for many plants and associated animals better adapted to more open environments. Examples of rare plants that are well represented in the Central Sand Plains and that are also strongly associated with barrens and sand prairie vegetation are the Wisconsin Endangered sand violet, the Wisconsin Threatened dwarf milkweed (*Asclepias ovalifolia*), and the Wisconsin Special Concern fameflower (*Talinum rugospermum*).

Nutrient-rich hardwood forests are rare in this ecological landscape, but some of the moist terraces along the Black River support an especially intact assemblage of herbs associated with mesic maple-basswood forests. These forests are ecologically important because intact stands of mesic hardwoods with diverse ground layers are relatively uncommon on state lands, and they are becoming increasingly impacted

Dwarf milkweed (Wisconsin Threatened) persists in remnant barrens and sand prairie habitats. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Sand violet (Wisconsin Endangered) occurs in barrens and sand prairie remnants at a few locations in central Wisconsin. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

by invasive plants, excessive browse pressure, and exotic earthworms. Several rare plants, such as Assiniboine sedge (*Carex assiniboinensis*) and beak grass (*Diarrhena americana*), occur on riverbanks and channel margins within the Floodplain Forests on the lower river terraces. Some terraces along the Black River, where steep bluffs adjoin the river's floodplain, are laced with seeps and flowing springs, which provide habitat for many additional native plants, including the globally rare and Wisconsin Threatened bog bluegrass.

The northern floristic component is best expressed in the dry and dry-mesic coniferous forests and in the acid peatland communities, which are found in the northernmost parts of the upper Midwest and across Canada. Pines are the prevalent conifers in the upland forests of the Central Sand Plains. Eastern hemlock (*Tsuga canadensis*) is very rare or absent from the western and southern portions of this ecological landscape, although it has been documented on a sandstone cliff within the Black River State Forest, in cold, moist sandstone gorges in the Wisconsin Dells area, and on heavier soils at a few locations in the northeastern part of the Central Sand Plains such as "Big Island" in the Wisconsin River just north of the city of Wisconsin Rapids.

Other habitat features in this ecological landscape with special importance to plants include bedrock exposures (see the "Physical Environment" section above) that host habitat specialists, including Wisconsin's only population of early anemone as well as rare species such as rock clubmoss (*Huperzia porophila*), maidenhair spleenwort (*Asplenium trichomanes*), and cliff cudweed. The latter is of especially great interest because recent work by plant taxonomists has indicated that this plant deserves recognition as a full species; this makes it one of the very few taxa known to be endemic to Wisconsin. Shadowy goldenrod, a plant of dry sandstone cliffs in unglaciated central and western Wisconsin, is endemic to the upper Midwest's Driftless Area.

Among the botanical oddities of the Central Sand Plains are naturally occurring populations of native plants in habitats that seem drastically out of place. For example, moist sandstone cliffs along the Wisconsin River in the southern part of the ecological landscape feature large populations of the ***bog ericad*** Labrador tea (*Ledum groenlandicum*). On other cliffs, we have documented the ***calciphilic*** shrubby cinquefoil (*Pentaphylloides floribunda*), a plant most often found in Calcareous Fen habitats of far eastern Wisconsin. In Wisconsin, bog fern typically grows in peaty wet-mesic eastern white pine-dominated forests in the Central Sand Plains, where it is disjunct from its main range in the north-

Significant Flora in the Central Sand Plains Ecological Landscape

- Important populations of native plants strongly associated with pine and oak barrens habitats occur here.
- Many disjunct plant species occur in the Central Sand Plains, including some with ranges centered on the Atlantic Coastal Plain of the eastern United States.
- Many of these disjuncts are wetland species; several occur primarily in rare wetland communities such as Coastal Plain Marsh and White Pine-Red Maple Swamp.
- Geographically limited habitat specialists occur on cliffs, along stream banks, and in spring seeps.
- The Wisconsin endemic, cliff cudweed, is represented in the Central Sand Plains by six of its ten documented populations.
- Terraces and seeps associated with river corridors support assemblages of plants found nowhere else in the Central Sand Plains.
- Impacts associated with the commercial harvest of native sphagnum mosses need additional study if such activities are to be done sustainably.

eastern U.S. At two locations in this ecological landscape, small populations of bog fern have been found on cool, moist (acid) sandstone cliffs.

Other plants with disjunct distributions are noteworthy in the Central Sand Plains. Both the aforementioned bog fern and long sedge are Wisconsin Special Concern plants that are far more abundant in this ecological landscape than anywhere else in the state (about 90% of documented occurrences, with by far the largest Wisconsin populations). Both of these species are strongly associated with the geographically restricted White Pine-Red Maple Swamp community. The core ranges of both species are in the northeastern United States.

One of only two state populations of the extremely rare and dramatically disjunct Wisconsin Endangered Lapland azalea occurs here. Far south of its primary range in central Canada, this species is also found at a handful of widely scattered locations in a few other states in the northeastern U.S.

Special mention must be made of a number of species with ranges centered in the Atlantic Coastal Plain of the eastern United States. Many of these Atlantic Coastal Plain disjuncts are rare in Wisconsin (several occur in no other ecological landscape), such as meadow beauty, twining screwstem, yellow screwstem, crossleaf milkwort, and reticulated nutrush. The natural habitats for these species are the open, saturated, sandy shorelines of small ponds on glacial lakebed or outwash landforms (especially the Coastal Plain Marsh community) as well as along game trails and the margins of small pools within open peatlands. Some members of this group may colonize, at least temporarily, disturbed sites such as ditches, borrow pits, and skid roads where the soils are sandy but moist, the immediate competition from more robust plants is low, and the water table is at or very close to the surface. Besides the Atlantic Coastal Plain disjuncts, other members of this unusual assemblage may include plants found in bogs or prairies, such as round-leaved sundew (*Drosera rotundifolia*), northern bog club-moss (*Lycopodium inundatum*), lance-leaved violet (*Viola lanceolata*), prairie blazing star (*Liatris pycnostachya*), the rare white colic-root (*Aletris farinosa*), grass pink (*Calopogon tuberosus*), rose pogonia (*Pogonia ophioglossoides*), club-spur orchid (*Platanthera clavellata*), and a large number of small native grasses and rushes.

Long sedge (Wisconsin Special Concern) is a rare plant of wet-mesic conifer forests in central Wisconsin, where it is disjunct from its primary geographic range in northeastern North America. Jackson County. Photo by Thomas Meyer, Wisconsin DNR.

Among the key natural disturbances that are factors in maintaining some of the more sensitive elements of the Central Sand Plains flora are fire in the drier uplands, periodic flooding along the major rivers and streams, and a high water table that through natural fluctuations periodically creates the moist open substrates needed by some of the habitat specialists. Small scale soil disturbances created by pocket gophers (*Geomys bursarius*), badgers (*Taxidea taxus*), and other burrowing animals create small patches of bare substrate (usually sand) that may be colonized by plants not known as vigorous competitors (examples include rarities such as sand violet and fameflower). Disturbed areas created by human activities are sometimes colonized by these and other specialists (Kirk 1996); however, such habitats may be quickly overrun by nonnative invasives such as spotted knapweed or cypress spurge. Human disturbances (e.g., ditch cleaning, clearing to develop haul roads used to transport timber, and borrow pit construction) can create habitats that may appear suitable for sensitive species, but these may be ephemeral and the benefits short-lived. Some of the cliff, barrens, wetland, and mesic hardwood forest rarities appear to do best in relatively intact natural communities.

Fauna

Changes in Wildlife over Time

Many wildlife populations have changed dramatically since humans arrived on the landscape, but these changes were not well documented before the mid-1800s. This section discusses only those wildlife species documented in the Central Sand Plains Ecological Landscape. Of those, this review is limited to species that were known or thought to be especially important here in comparison to other ecological landscapes. For a more complete review of historical wildlife

in the state, see *Wildlife in Early Wisconsin: A Collection of Works by A. W. Schorger* (Brockman and Dow 1982).

The Central Sand Plains Ecological Landscape was important historically for a number of wildlife species—especially those using extensive wetlands, oak and pine barrens, oak openings, oak forests, and pine forests. This ecological landscape was particularly important for the Passenger Pigeon (*Ectopistes migratorius*), Sharp-tailed Grouse, gray wolf (*Canis lupus*), and, possibly, the Kirtland's Warbler (*Setophaga kirtlandii* but listed as *Dendroica kirtlandii* on the Wisconsin Natural Heritage Working List). In addition, today it is important for Trumpeter Swan (*Cygnus buccinators*), Whooping Crane (*Grus Americana*), and Greater Prairie-Chicken. Wildlife populations changed following logging of the forests during the state's ***Cutover***, settlement by Euro-Americans, draining of many wetlands in the late 19th and early 20th century, and wildfire prevention and control.

Although the distribution of the Passenger Pigeon has been described as covering the eastern half of North America (Schorger 1946), nesting was limited by the presence and abundance of mast (primarily beech nuts and acorns). Schorger (1946) reported from newspaper accounts and interviews that Passenger Pigeons nested by the millions in Wisconsin. With a large presence of oak, this ecological landscape was undoubtedly an important nesting area for Passenger Pigeons during years of high mast production. One of the largest recorded nestings of the Passenger Pigeon occurred in 1871 in the "scrub oaks" of this ecological landscape (Schorger 1937). The nesting area covered 544,000 acres and was estimated to contain 136,000,000 Passenger Pigeons (Figure 10.7). Passenger Pigeons were shot and trapped during the nesting season, and squabs were taken from nests and shipped to markets in Milwaukee, Chicago, and cities on the east coast by the trainload (Schorger 1937). Since the Passenger Pigeon probably laid only one egg each year, nested communally, and was dependent on abundant mast to produce young, the heavy kill of the Passenger Pigeon led to its extinction. The last known Passenger Pigeon died in 1914 at the Cincinnati Zoo.

The gray wolf was found statewide before widespread Euro-American settlement but declined gradually due to loss of food sources, shooting, trapping, and poisoning. By the early 1960s, the gray wolf was thought to be extirpated from the state. The wolf population has since become reestablished from wolves immigrating from Minnesota and Michigan and has expanded from northwestern to northeastern Wisconsin and into central Wisconsin. In 2008–09, this ecological landscape had a total population of 88–92 gray wolves in 20 packs, plus one lone wolf. The wolf population has continued to grow, with a statewide population estimated at over 800 gray wolves in 2012 (A.P. Wydeven, Wisconsin DNR, personal communication).

The globally endangered Kirtland's Warbler may have been present in this ecological landscape before Euro-American settlement, based on available habitat. Reports of male Kirtland's Warbler in this ecological landscape have occurred over the last two decades, and it has been observed nesting here since at least 2007 (Trick and Grveles 2010). The Central Sand Plains has high potential to provide habitat for an additional breeding population of the Kirtland's Warbler outside of their core breeding range in Michigan.

The Sharp-tailed Grouse was considered widely distributed in the state in open and brushy habitats before Euro-American settlement. It was common in this ecological landscape, primarily occupying extensive oak openings, brush, and barrens (Schorger 1943). Sharp-tailed Grouse

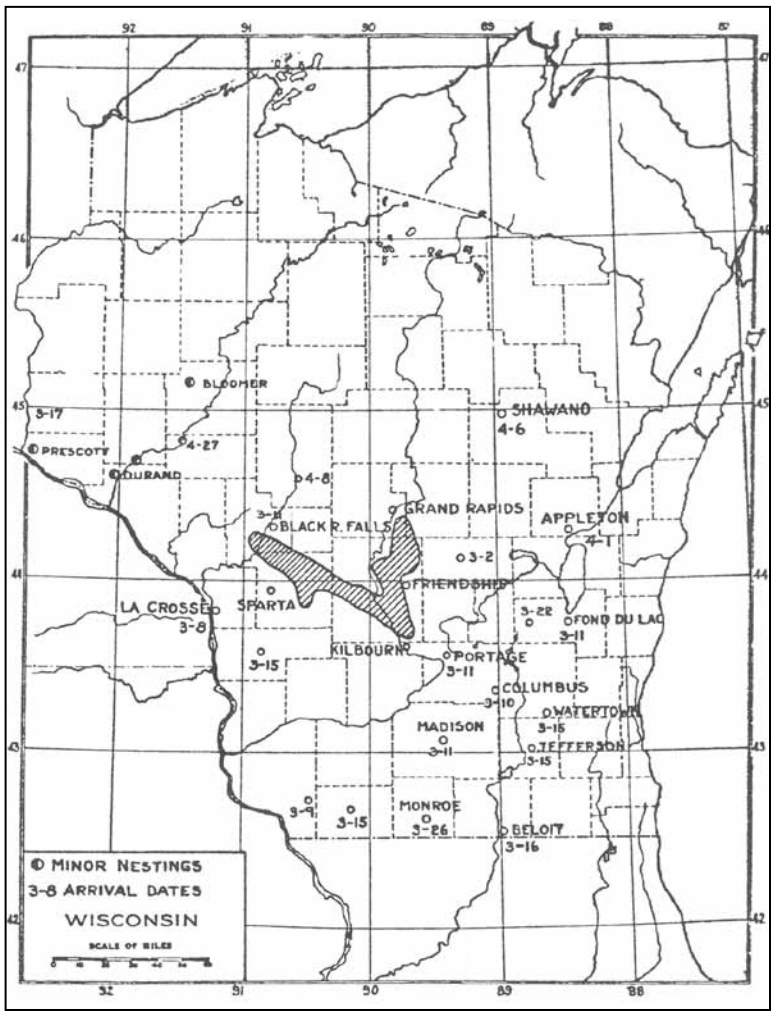


Figure 10.7. *Location and extent of Wisconsin Passenger Pigeon nesting in 1871. Figure reproduced from Schorger (1937) by permission of the Linnean Society of New York.*

expanded into areas they had not previously inhabited during and shortly after the Cutover. Later populations declined as a result of reforestation and/or the expansion of intensive agriculture (Gregg and Niemuth 2000) (see the "Changes to Fauna" section in Chapter 4, "Changes and Trends in Ecosystems and Landscape Features," in Part 1 of the book). In addition, wildfire prevention allowed barrens and oak openings to succeed to dense forests, causing further population declines. Today there are few Sharp-tailed Grouse present in the ecological landscape. Most of them are now associated with large open wetlands, but the total population is very small. Only two or three male Sharp-tailed Grouse were observed on the leks at Dike Seventeen Wildlife Area during 2002–2007. Only one male was observed in 2008 and none in 2009 and 2010. However, there is some potential to restore barrens habitats and other potentially suitable habitats at a scale that may allow Sharp-tailed Grouse populations to recover.

Prior to the mid-1800s and the expansion of Euro-American settlement, the Greater Prairie-Chicken occurred throughout southern Wisconsin, although the Sharp-tailed Grouse may have been more abundant (Schorger 1943). The Greater Prairie-Chicken was considered abundant through the 1850s in southern Wisconsin but then declined. At first, expanding agriculture seemed to increase Greater Prairie-Chicken populations, but as agriculture became more intensive, suitable habitat declined and populations also declined. The result was that the range of the Greater Prairie-Chicken moved north as prairies were plowed for agriculture in the south and forests were cleared in central and northern Wisconsin. As forests regenerated in the north, the Wisconsin range of the Greater Prairie-Chicken constricted to its present size and location, and it now occurs primarily in the eastern part of the Central Sand Plains Ecological Landscape. During 2003–2013, a mean of approximately 400 male Greater Prairie-Chickens were counted on booming grounds in central Wisconsin, with 295 male Greater Prairie Chickens counted in 2013.

The area-sensitive Greater Prairie-Chicken (Wisconsin Threatened) can no longer find sufficient habitat in any of Wisconsin's native grasslands. Its continued existence here is dependent on intensive management of large areas of nonnative grass, mostly in central Wisconsin. Photo courtesy of U.S. Fish and Wildlife Service.

Trumpeter Swans were once fairly common throughout most of the northern United States and Canada. Market hunting and the millinery trade rapidly depleted nesting populations during the 19th century (Wisconsin DNR 1997). Swan skins were sold as part of the fur trade to Euro-Americans, where they were used to make ladies' powder puffs, and the feathers were used to adorn fashionable hats.

The Trumpeter Swan nested in Minnesota and Wisconsin until the 1880s. In Minnesota, the species occurred in the prairies and "prairie-parkland" areas of western, central, and northern portions of the state. In Wisconsin, the Trumpeter Swan may have nested in all but the northeastern forested regions, most likely in large marshes associated with shallow lakes. Elsewhere in the Midwest, the Trumpeter Swan's historical breeding range reached from western Nebraska to central Michigan and extended as far north and east as James Bay in Canada (Wisconsin DNR 1997). By 1900 the Trumpeter Swan was thought to be extinct. However, a small population survived in the mountain valleys of Montana, Idaho, and Wyoming as well as in remote parts of Alaska and Canada. Since then there has been a concerted effort to restore the species. Trumpeter Swans were recently reintroduced at Sandhill Wildlife and Demonstration Area within the Central Sand Plains and in several other parts of the state. Breeding pairs now occupy Sandhill and other nearby sites, and a self-sustaining population has been established in the region.

The Whooping Crane likely migrated through Wisconsin before Euro-American settlement. Kumlien and Hollister (1903) stated that limited historical records indicate Whooping Cranes may have migrated through Wisconsin and may have been "breeding to some extent." There was an unconfirmed report of a Whooping Crane nest in Brown County, Wisconsin (Carr 1890) and a confirmed report of a nest in Dubuque County, Iowa, adjacent to Grant County, Wisconsin (Allen 1952). There were five reports of Whooping Crane sightings between1840 and 1850 (Allen 1952), occasional sightings in western Wisconsin, and 12 sightings in southeastern Wisconsin (Hoy 1885). In addition, observations were reported from the southwestern portion of Wisconsin on the Mississippi River, a specimen was collected adjacent to the Sugar River in Green County, and there was a sighting in 1884 at Twin Bluffs in Juneau County (Kumlien and Hollister 1903). It is thought that the Whooping Crane was quickly eliminated from the Midwest soon after Euro-American settlement in the mid-19th century.

Since 1999 Wisconsin has played a major role in efforts to restore a migratory Whooping Crane population in eastern North America. A core breeding area was established in this ecological landscape at Necedah National Wildlife Refuge.

Necedah National Wildlife Refuge was chosen because of the large number of suitable wetlands as habitat and the controlled access to the National Wildlife Refuge that could prevent human disturbance. There were approximately 75 Whooping Cranes in the Eastern Migratory Population in 2008, with plans for 25–30 birds to be added to the population each year until it becomes self-sustaining, perhaps by 2020. Two release methods are being used to rebuild the population. Initially, all captive-reared Whooping Crane chicks were conditioned to follow an ultralight aircraft from Necedah National Wildlife Refuge to Chassahowitzka National Wildlife Refuge on the Gulf coast of Florida. These birds then return to Wisconsin and make subsequent migrations south unaided. Beginning in autumn 2005, this program was supplemented with the direct release of Whooping Crane chicks into groups of Whooping or Sandhill Cranes (*Grus canadensis*) in central Wisconsin. The chicks follow birds from Wisconsin to the southern U.S., following birds that already know the migration route. This restoration effort is under the direction of a management plan by the Whooping Crane Eastern Partnership (Wisconsin DNR 2006d).

As part of the effort to reestablish a resident flock of Whooping Cranes in Wisconsin, ultralight aircraft leads young cranes from central Wisconsin to their Florida wintering grounds. Photo courtesy of Kim Mitchell, Whooping Crane Eastern Partnership.

An attempt is being made to restore a breeding population of the globally imperiled Whooping Crane to remote portions of the Central Sand Plains. Photo courtesy of Kim Mitchell, Whooping Crane Eastern Partnership.

As of mid-October 2009, there were at least 65 Whooping Cranes present in 10 Wisconsin counties, centered on this ecological landscape. Whooping Cranes spend the summer months mostly in places within the Central Sand Plains, such as Necedah National Wildlife Refuge, Mill Bluff State Park, Black River State Forest, and Meadow Valley, Sandhill, and McMillan Marsh Wildlife Areas, but they have been observed in many other parts of the state. At least nine breeding pairs of Whooping Cranes attempted nesting in April 2010, with most of the nests located on Necedah National Wildlife Refuge and one nest on a private cranberry operation. All early nests failed in 2010 due to abandonment; however, three late-season nests and four renests have produced six Whooping Crane chicks on and around Necedah National Wildlife Refuge. The nest abandonment pattern observed in 2010 was similar to what has been observed since 2005. The causes for the abandonment have not been identified, but ongoing studies should provide helpful information. In 2010, video surveillance was conducted at all but one whooping crane nest, and biting insect data were collected at all failed whooping crane nests. See the Whooping Crane Eastern Partnership website for updates (WCEP 2013).

Significant Wildlife

Wildlife are considered significant for an ecological landscape if (1) the ecological landscape is considered important for maintaining the species in the state and/or (2) the species provides important recreational, social, and economic benefits to the state. To ensure that all species are maintained in the state, "significant wildlife" includes both common species and species that are considered "rare" (in this publication, "rare" includes species listed as endangered or threatened by either the State of Wisconsin or the federal government or species that are listed as Special Concern by the State of Wisconsin). Four categories of species are discussed: rare species, Species of Greatest Conservation Need (SGCN), responsibility species, and socially important species (see definitions in text box). Because the conservation of wildlife communities and habitats is the most efficient way to manage and benefit a majority of species, we also discuss the management of different wildlife habitats in which significant fauna occur.

Rare Species. As of November 2009 (Wisconsin DNR 2009), the Wisconsin Natural Heritage Working List documented 116 rare species within this ecological landscape, including 6 mammals, 29 birds, 11 herptiles, 11 fishes, and 59 invertebrates (see Appendix 10.D). These include three species that are also listed as U.S. Endangered species and two species being considered for federal listing. Of the 116 rare species, 13 are Wisconsin Endangered species, 20 are Wisconsin Threatened species, and 83 are Wisconsin Special Concern species (two of the federally listed species are also Wisconsin

Categories of Significant Wildlife

- **Rare species** are those that appear on the Wisconsin DNR's Natural Heritage Working List as Wisconsin or U.S. Endangered, Threatened, or Special Concern.
- **Species of Greatest Conservation Need** are described and listed in the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b) as those native wildlife species that have low or declining populations, are "indicative of the diversity and health of wildlife" of the state, and need proactive attention in order to avoid additional formal protection.
- **Responsibility species** are both common and rare species whose populations are dependent on Wisconsin for their continued existence (e.g., a relatively high percentage of the global population occurs in Wisconsin). For such a species to be included in a particular ecological landscape, a relatively high percentage of the state population needs to occur there, or good opportunities for effective population protection and habitat management for that species occur in the ecological landscape. Also included here are species for which an ecological landscape holds the state's largest populations, which may be critical for that species continued existence in Wisconsin even though Wisconsin may not be important for its global survival.
- **Socially important species** are those that provide important recreational, social, or economic benefits to the state for activities such as fishing, hunting, trapping, and wildlife watching.

Special Concern species, and one is also Wisconsin Endangered). See Appendix 10.C for a complete list of rare species occurring within this ecological landscape.

■ ***Federally Listed Species:*** Three federally listed animals occur in this ecological landscape. The Karner blue butterfly (*Lycaeides melissa samuelis*) is listed as U.S. Endangered and occurs here in barrens remnants and sand prairies. It is managed under a Habitat Conservation Plan (HCP) approved by the U.S. Fish and Wildlife Service. The U.S. Endangered Kirtland's Warbler has been found breeding in this ecological landscape and is being monitored (see the "Responsibility Species" section below). At the state level, the Karner blue butterfly and Kirtland's Warbler are listed as Wisconsin Special Concern species. The gray wolf, which occurs in this ecological landscape, was removed from the federal Endangered Species list in January 2012, granting management authority to the State of Wisconsin. The Wisconsin state legislature passed a law in April 2012 authorizing hunting and trapping seasons for wolves and directed that wolf hunting and trapping seasons be held starting in the fall of 2012. The first hunting and trapping seasons of wolves were therefore conducted during October-December 2012. Wolves are now being managed under a 1999 wolf management plan (Wisconsin DNR 1999) with addenda in 2006 and 2007, but the plan is being updated to reflect these recent changes in wolf management in Wisconsin. The eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) is being considered for federal listing, as is the bullhead (sheepnose) mussel (*Plethobasus cyphyus*). Both are found here and are listed as Wisconsin Endangered species. The Whooping Crane is listed as U.S. Endangered and has been reintroduced at Necedah National Wildlife Refuge to reestablish a migratory flock in the eastern part of the country. The Whooping Crane is listed as an "experimental nonessential population" as of 2009 and is considered a Wisconsin Special Concern species. The Bald Eagle (*Haliaeetus leucocephalus*) (formerly U.S. Threatened) breeds here and winters along the Wisconsin River. After its recent delisting, this species is now federally protected with a required monitoring program for five years to ensure that populations do not decline. The Bald Eagle is further protected under the U.S. Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act. The Bald Eagle is now listed as a Wisconsin Special Concern species.

■ ***Wisconsin Endangered Species:*** The following Wisconsin Endangered species occur in this ecological landscape: Four birds, including Loggerhead Shrike (*Lanius ludovicianus*), Red-necked Grebe (*Podiceps grisegena*), Forster's Tern (*Sterna forsteri*), and Barn Owl (*Tyto alba*); four herptiles, including northern cricket frog (*Acris crepitans*), slender glass lizard (*Ophisaurus attenuatus*), eastern massasauga rattlesnake, and ornate box turtle (*Terrapene ornata*); two mussels, the bullhead/sheepnose and purple wartyback (*Cyclonaias tuberculata*); and three invertebrates, including the phlox moth (*Schinia indiana*), regal fritillary (*Speyeria idalia*), and warpaint emerald dragonfly (*Somatochlora incurvata*). No Wisconsin Endangered mammals or fishes occur in this ecological landscape.

The globally rare regal fritillary (Wisconsin Endangered) occupies portions of the Buena Vista grasslands. Photo by Mike Reese.

■ ***Wisconsin Threatened Species:*** No Wisconsin Threatened mammals occur in this ecological landscape. Nine Wisconsin Threatened birds have been documented within the Central Sand Plains Ecological Landscape, including Henslow's Sparrow (*Ammodramus henslowii*), Great Egret (*Ardea alba*), Red-shouldered Hawk (*Buteo lineatus*), Cerulean Warbler (*Setophaga cerulea* but listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List), Acadian Flycatcher (*Empidonax virescens*), Yellow-crowned Night-Heron (*Nyctanassa violacea*), Kentucky Warbler (*Geothlypis formosa* but listed as *Oporornis formosus* on the Natural Heritage Working List), Greater Prairie-Chicken, and Bell's Vireo (*Vireo bellii*). Other Wiscconsin Threatened species that occur here include two herptiles—wood turtle (*Glyptemys insculpta*) and Blanding's turtle (*Emydoidea blandingii*); five Wisconsin Threatened fishes—blue sucker (*Cycleptus elongatus*), redfin shiner, shoal chub (*Macrhybopsis aestivalis*); river redhorse, and gilt darter; two mussels—salamander mussel (*Simpsonaias ambigua*) and buckhorn mussel (*Tritogonia verrucosa*); and two insects—frosted elfin (*Callophrys irus*) and prairie leafhopper (*Polyamia dilata*).

The globally rare frosted elfin (Wisconsin Threatened) occupies pine and oak barrens remnants in which this butterfly's larval food plant, wild lupine, is common. Photo by Mike Reese.

The Wisconsin range of the globally rare ringed boghaunter dragonfly (Williamsonia lintneri) *(Wisconsin Special Concern) is limited to intact peatlands of central Wisconsin. Photo by Karl Legler.*

■ ***Wisconsin Special Concern Species:*** Wisconsin Special Concern species occurring in this ecological landscape include 6 mammals, 16 birds, 5 herptiles, 6 fishes, and 50 invertebrates.

■ **Species of Greatest Conservation Need.** Species of Greatest Conservation Need (SCGN) appear in the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b) and include those species already recognized as Endangered, Threatened, or Special Concern on state or federal lists along with nonlisted species that meet the SGCN criteria. There are 55 birds, 9 mammals, 10 herptiles, and 3 fishes listed as SGCN for the Central Sand Plains Ecological Landscape (see Appendix 10.E for the complete list of Species of Greatest Conservation Need in this ecological landscape).

■ **Responsibility Species.** The Central Sand Plains and Forest Transition ecological landscapes are the only places in the state where populations of Greater Prairie-Chicken persist. The Central Sand Plains is also important to other grassland bird species such as Upland Sandpiper (*Bartramia longicauda*), Northern Harrier (*Circus cyaneus*), Short-eared Owl (*Asio flammeus*), Vesper Sparrow (*Pooecetes gramineus*), and Henslow's Sparrow. The Henslow's Sparrow has been declining in many parts of its range and now occurs as a breeder only in the central Midwest. Wisconsin has an opportunity to help sustain this species, and the Central Sand Plains Ecological Landscape can provide important habitat.

Significant Wildlife in the Central Sand Plains Ecological Landscape

- Whooping Crane, Sandhill Crane, Trumpeter Swan, Greater Prairie-chicken, Kirtland's Warbler, Sharp-tailed Grouse, Henslow's Sparrow, gray wolf, eastern massasauga, Karner blue butterfly, ringed boghaunter dragonfly, and warpaint emerald dragonfly
- Species using extensive pine and oak barrens, pine-oak forest, floodplain forest, acid peatlands, sedge meadows, surrogate grasslands, and sand prairie
- Wide-ranging species that use extensive undeveloped habitats (such as gray wolf, fisher, and black bear) and numerous area-sensitive species
- Lake sturgeon, river redhorse, gilt darter, redfin shiner, and muskellunge
- Salamander mussel and bullhead (sheepnose) mussel

The Central Sand Plains is one of only three ecological landscapes where large-scale management for Oak and Pine Barrens communities and associated species is feasible. Species for which it is important to manage in this ecological landscape that use oak and pine barrens include Sharp-tailed Grouse, gophersnake (*Pituophis catenifer*), slender glass lizard, phlox moth, frosted elfin, and the U.S. Endangered Karner blue butterfly. Wisconsin has a large portion of the global population of Karner blue butterfly within its borders. This ecological landscape is an important place to manage for them because of the number of existing populations, amount of suitable habitat, extensive public land holdings, and the significant restoration opportunities that are present. The Karner Blue Butterfly Habitat Conservation Plan, developed by a number of public and private partners and approved by the U.S. Fish and Wildlife Service, guides management of this U.S. Endangered species on both public and private lands. The Wisconsin Threatened frosted elfin uses the same larval host plant as the Karner blue butterfly, wild lupine, and is actually a much rarer species in Wisconsin than the Karner blue (however, it is more common in some other parts of its range and has not been federally listed). The frosted elfin is now recognized as globally rare.

Red-headed Woodpecker (*Melanerpes erythrocephalus*) and Eastern Whip-poor-will (*Caprimulgus vociferus*) populations have been declining statewide. Both species have significant populations in this ecological landscape, where they use extensive open oak and pine forests and savannas (including barrens) as breeding habitat. The Yellow-billed Cuckoo (*Coccyzus americanus*), which is also declining, uses open deciduous woodlands (such as some Floodplain Forests), often near rivers or slow moving creeks. The Golden-winged Warbler (*Vermivora chrysoptera*), for which Wisconsin and Minnesota have the majority of the global population, occurs here in lowland shrub habitats. The American Woodcock (*Scolopax minor*) is also abundant in these shrubby habitats.

The restoration of a breeding population of the U.S. Endangered Whooping Crane is being attempted in this ecological landscape, and special attention needs to be paid to this species and its habitats. The Trumpeter Swan is also being restored in this ecological landscape and maintenance of open wetland habitats is especially important. Other open wetland habitat species important in this ecological landscape include American Bittern (*Botaurus lentiginosus*), Northern Harrier, Le Conte's Sparrow (*Ammodramus leconteii*), Sedge Wren (*Cistothorus platensis*) and Blanding's turtle. Wisconsin is in the core continental range of the declining Sedge Wren, and this ecological landscape is important to sustaining its continental population.

The eastern massasauga rattlesnake has declined substantially since Euro-American settlement, and the Central Sand Plains population needs special attention (including surveys, monitoring, a conservation plan, and management actions). The eastern massasauga rattlesnake is a Wisconsin Endangered species, occupying floodplain habitats and other wetland types and some associated uplands. Other floodplain species of importance in this ecological landscape are the Prothonotary Warbler (*Protonotaria citrea*) and Red-shouldered Hawk, both inhabitants of extensive stands of mature floodplain forest. Red-shouldered Hawks also breed in older stands of upland pine-oak forest, usually, but not always, near wetlands.

The gray wolf has established its most southerly population in the state here, and opportunities to maintain this species in the Central Sand Plains are very good.

Population declines of the eastern massasauga rattlesnake (Wisconsin Endangered) are due to habitat loss and human persecution. A few populations persist in the Central Sand Plains. Photo by Rori Paloski, Wisconsin DNR.

Vast forests and wetlands, low human population and road densities, and extensive public lands are among the factors that have permitted recolonization of the Central Sand Plains by the gray wolf. Photo by Gary Kramer, courtesy of U.S. Fish and Wildlife Service.

The U.S. Endangered Kirtland's Warbler has recently been found nesting in dry pine forests in the Central Sand Plains Ecological Landscape (Trick and Grveles 2010), and efforts are underway to assess and maintain this population. In the summer of 2007, three nests were found in this ecological landscape, and in the summer of 2008, five nests were found here. At least 10 Kirtland's warbler nesting attempts were documented in the Central Sand Plains during 2009. In 2010, 16 nests were documented, which fledged 12–18 young (because of late nesting, the outcome of some nests was not determined in 2010). Cowbird parasitism and predation were the main causes of nest loss. The Central Sand Plains has high potential to provide habitat for and an additional breeding population of the Kirtland's Warbler.

Socially Important Fauna. Species such as white-tailed deer (*Odocoileus virginianus*), American black bear (*Ursus americanus*), American beaver, North American river otter *(Lutra canadensis)*, Ruffed Grouse (*Bonasa umbellus*), American Woodcock, Wild Turkey (*Meleagris gallopavo*), Greater Prairie-Chicken, Bald Eagle, Sandhill and Whooping Cranes are all important here for hunting, trapping, and wildlife viewing. This ecological landscape has an important warmwater fishery that supports populations of walleye (*Stizostedion vitreum*) and smallmouth (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) as well as bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and other panfish sought by anglers. Coolwater reaches of the Black River support populations of muskellunge (*Esox masquinongy*). There are coldwater streams supporting populations of native brook trout (*Salvelinus fontinalis*) as well as introduced brown trout (*Salmo trutta*).

Wildlife Habitat and Communities. The Central Sand Plains Ecological Landscape contains important wildlife species associated with the high density and abundance of wetlands (tamarack-black spruce swamp, White Pine-Red Maple Swamp, Open Bog-Poor Fen-Muskeg, sedge meadow, marsh, Alder Thicket, and Floodplain Forest), surrogate grasslands, barrens, and dry pine, oak, or mixed forests. The Central Sand Plains Ecological Landscape has the potential to continue supporting wide-ranging species favoring or requiring extensive forest, wetland, or grassland habitats. Species such as the gray wolf are now established in the ecological landscape, and other wide ranging species like the fisher (*Martes pennanti*), black bear, and Northern Goshawk (*Accipiter gentilis*) also occur here.

Six Important Bird Areas have been designated within or partially within the Central Sand Plains Ecological Landscape (Steele 2007). The large expanses of dry conifer forest support populations of conifer-associated birds such as Connecticut Warbler (*Oporornis agilis*), Blue-headed Vireo (*Vireo solitarius*), Red Crossbill (*Loxia curvirostra*), Hermit Thrush (*Catharus guttatus*), and Nashville Warbler (*Oreothlypis ruficapilla*), and the U.S. Endangered Kirtland's Warbler.

Historically, this ecological landscape was important to species using oak savanna (this term includes oak barrens) habitats. One species that extensively used this habitat, the Passenger Pigeon, is now extinct. Most oak savanna habitat has succeeded to oak forest due to the lack of fire or has been cleared for agricultural purposes. Oak savanna habitats retaining scattered large oaks are especially important to Red-headed Woodpecker, Orchard Oriole (*Icterus spurious*), and Eastern Bluebird (*Sialia sialis*).

Pine and Oak Barrens (and Sand Prairie habitats) were historically abundant in this ecological landscape. Fire suppression has allowed most of this habitat to succeed to oak-pine forest, or the barrens have been converted to pine plantations. Where barrens exist, they are important for Sharp-tailed Grouse (if large habitat patches are available), Common Nighthawk (*Chordeiles minor*), Eastern Towhee (*Pipilo erythrophthalmus*), Brown Thrasher (*Toxostoma rufum*), Clay-colored Sparrow (*Spizella pallida*), gophersnake, North American racer (*Coluber constrictor*), slender glass lizard, Blanding's turtle, phlox moth, frosted elfin, and the U.S. Endangered Karner blue butterfly.

There are large areas of surrogate grasslands in the eastern half of the ecological landscape, including several large publicly owned properties (Buena Vista and Leola Marsh Wildlife Areas) as well as a major DNR initiative to restore additional grasslands here (Central Wisconsin Grasslands Conservation Area). The grasslands here, which were historically conifer swamp and open wetland rather than prairie and savanna, are now important for many other rare and common grassland birds such as the Wisconsin Threatened Greater Prairie-Chicken, Upland Sandpiper, Short-eared Owl, and Henslow's Sparrow. Several other rare taxa occur here, including one of the state's largest populations of the globally rare, the Wisconsin Endangered regal fritillary butterfly.

Shrub-dominated wetlands (Alder Thicket and Shrub-carr) are abundant in this ecological landscape and support populations of Golden-winged Warbler, American Woodcock, Veery (*Catharus fuscescens*), Mourning Warbler (*Geothlypis philadelphia*), Alder Flycatcher (*Empidonax alnorum*), wood turtle, and snowshoe hare (*Lepus americanus*).

There are extensive open wetlands of sedge meadow, poor fen and emergent marsh here, and they are important to Whooping Crane, Sandhill Crane, Trumpeter Swan, American Bittern, Northern Harrier, Henslow's Sparrow, Le Conte's Sparrow, Sedge Wren, eastern massasauga rattlesnake, and the globally rare ringed boghaunter dragonfly.

Three major floodplain corridors occur in the Central Sand Plains, along the Wisconsin, Black, and Yellow rivers. The floodplains and associated lowland hardwood forests provide habitat for species such as Red-shouldered Hawk, Cerulean Warbler, Prothonotary Warbler, and Yellow-billed Cuckoo. Riverine ponds, oxbow lakes, and cutoff sloughs within the big river floodplains provide significant habitat for many fish, amphibians, and invertebrates. They are also important foraging areas for mammals and birds.

Over the past half century, migrating Sandhill Cranes have rebounded from extremely low numbers and are once again a common sight in parts of Wisconsin, including the Central Sand Plains. Photo by Wisconsin DNR staff.

Aquatic habitats and wetlands support Trumpeter Swan, Black Tern (*Chlidonias niger*), Ring-necked Duck (*Aythya collaris*), Common Loon (*Gavia immer*) (at its southernmost range limits), wood turtle, and the midland smooth softshell turtle (*Apalone muticus*).

Streams in this ecological landscape support populations of the Wisconsin Threatened river redhorse, gilt darter, and redfin shiner. Below Black River Falls, the Black River supports a population of lake sturgeon (*Acipenser fulvescens*). Redside dace (*Clinostomus elongatus*) and western sand darter (*Etheostoma clarum*) make homes in reaches of higher quality streams here. A number of coldwater streams continue to support self-sustaining populations of native brook trout.

The East Fork of the Black River is noted for its good water quality, intact associated habitats along the lower river, and diverse assemblages of fish and invertebrates. The lower Lemonweir River supports a population of the globally rare salamander mussel, and a segment of the Wisconsin River holds an experimentally restored population of this species. Other stretches of the Wisconsin River support populations of the globally rare western sand darter. The Yellow River, below the Lake Dexter Dam in Wood County, supports the Central Sand Plains' only confirmed population of the Wisconsin Threatened river redhorse. Many of the smaller creeks exhibit significant biological diversity. For example, Robinson Creek within the Black River State Forest has 60 documented invertebrate species and 32 fish species, and Morrison Creek (also within the Black River State Forest) supports a large number of Wisconsin Special Concern species, including the Wisconsin endemic sand snaketail dragonfly (*Ophiogomphus smithi*).

Natural and Human Disturbances

Fire, Wind, and Flooding

Historically, fire was the most extensive natural disturbance in the Central Sand Plains as evidenced by soils, topography, past and present vegetation, and the frequency and size of fires during recorded history. Present-day fires are typically ignited by humans, but these spread and develop into large fires only in areas with dry sandy soils that lack firebreaks such as streams, lakes, and wetlands (Cardille et al. 2001). The presence of barrens and savannas early in the Euro-American settlement period indicates that fires were formerly very frequent in much of the ecological landscape. Most of the upland vegetation here is adapted to periodic fire disturbance.

Many notable fires have occurred here during the past 150 years (Figure 10.8), including a 1930 fire that burned 500 square miles and left huge holes in the organic soils of peatlands. This fire eliminated nearly all evidence of settlement and agriculture, and set the stage for abandonment of burned farmlands and their purchase by federal and state governments. Some of the major fires included the following:

- 1893 – "a disastrous fire which eliminated most of the remaining tamarack and spruce in the bogs" (USFWS 2004)
- 1910 – "fire burned large acreages of wild lands"
- 1920 – "widespread fire covered much of the area"
- 1930 – "the most extensive and severe fire in the history of the area… burned more than 300,000 acres"
- 1948 – Colburn fire in Adams County, 5,126 acres
- 1948 – Bear Bluff fire in Jackson County, partly on the Black River State Forest, 2,940 acres
- 1949 – Armenia #1 fire in Juneau County, 3,194 acres
- 1953 – Adams fire in Adams County, 1,584 acres
- 1957 – Monroe Center fire in Adams County, 1,780 acres
- 1959 – Armenia #2 fire in Juneau County, 1,313 acres
- 1976 – New Miner #1 fire in Juneau County, 3,177 acres
- 1977 – New Miner #3 fire in Juneau County, 1,200 acres
- 1977 – Saratoga fire in Wisconsin Rapids, 6,159 acres and 90 buildings
- 1977 – Brockway fire in Black River Falls, 17,590 acres
- 1980 – Lyndon Station #2 fire in Juneau County, 1,028 acres
- 1988 – Lyndon Station fire in Juneau County, 911 acres and three buildings
- 2005 – Cottonville fire, 3,410 acres, 30 houses, and over 60 outbuildings

Note: *1893–1930 fire information is taken from U.S. Fish and Wildlife Service (2004); 1948–2005 fire information is from Wisconsin DNR Forest Fire Program records.*

Studies of fire history prior to Euro-American settlement are lacking in this ecological landscape. Comparisons to other fire-prone landscapes in the Lake States are problematic because this area receives less precipitation than similar landforms in Lower Michigan, and the climate is warmer than the sand plains of northern Wisconsin. Features of the original landscape that influenced the ability for fire to spread have

been modified by drainage in some areas and impoundments in others, and peatlands have lost surface elevation due to repeated fires, oxidation, and decomposition during the last century. These changes make it difficult to estimate original fire intervals and intensities. Before Euro-American settlement, the frequency of recurrence of stand-replacing fires (fire intervals) ranged from 75 to 250 years for parts of the Lake States with diverse landscape firebreaks and mixed pine-oak-aspen forests (Dickmann and Cleland 2002). In northeastern Lower Michigan, historical fire intervals in mixed pine forests were 129–258 years, and in oak-pine forests, fire intervals were 172–344 years (Whitney 1986). Fire intervals of 83–167 years were typical of jack pine forests in Michigan, based on federal General Land Office (GLO) Public Land Survey data, which would not have included small areas or lighter burns (Whitney 1986). Simard and Blank (1982) found that fire intervals for jack pine forests in the highly flammable Mack Lake area of Michigan averaged 27 years during the time period prior to Euro-American settlement. At Itasca State Park in Minnesota, jack pine forests burned at an interval of about 22 years (Frissell 1973).

Various tribes of American Indians have occupied the Central Sand Plains since the last glacial period, utilizing the food resources of the area, cultivating crops on the fertile floodplains, and building settlements on higher landforms. These tribes used fire as a tool in creating desirable vegetation, clearing land, driving game, and for other reasons. Modern data on lightning strikes (1982–2003) show relatively few occurrences in most of the low-lying landscape of the Central Sand Plains, although the incidence is slightly higher in Wood and Portage counties (NOAA 2007). It is very likely that before Euro-American settlement fire intervals in this ecological landscape had a strong human influence.

We know that fire was a frequent occurrence in the Central Sand Plains prior to Euro-American settlement and that fire return intervals varied somewhat depending on soils, water tables, and patch sizes of flammable vegetation. In the driest portions of the ecological landscape, where vegetation was dominated by oak barrens or jack pine-oak barrens, experts believe that stand-replacing fires occurred at roughly 25–50 year intervals, along with low-intensity surface fires at intervals of two to four years (A. Haney, professor emeritus, UW-Stevens Point, personal communication). In mixed pine-oak systems that developed into savanna or forest, surface

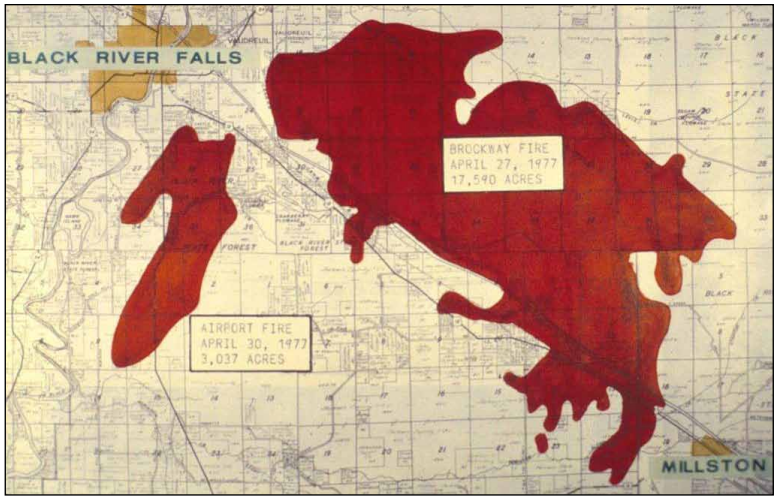


Figure 10.8. *The map shows the extent of the 1977 Brockway fire, illustrating the large size of some wildfires in this ecological landscape. Each square is 1 square mile.*

fires would have occurred somewhat less frequently, perhaps every 7–10 years. These fire intervals are estimated based on information from other parts of the Midwest and on studies of prescribed burning used to recreate the structure and composition of barrens (Reich et al. 1990, Nielsen et al. 2003). Longer stand-replacing fire intervals of 75–250 years, in combination with relatively frequent surface fires, would have been likely in areas with fire barriers of streams, lakes, and wetlands, leading to development of dominantly eastern white pine or swamp forests. Wetlands also would have burned when very dry conditions were accompanied by strong winds, as is sometimes seen in modern fires (e.g., the Ham Lake fire in Minnesota in May 2007).

Prescribed burning has been used in the ecological landscape to restore grassland and barrens, but in some areas the presence of homes and other structures and/or dense, highly flammable vegetation makes the use of fire difficult. Managers often regenerate pine forests through clearcutting, which partially resembles the effects of fire, as both are disturbances that open the site to full sunlight. Fire is different from clearcutting in that it reduces the density of saplings, shrubs, and herbaceous litter, providing a competitive advantage for some regenerating tree (e.g., oak) and herb species. Fire also mineralizes organic material, making nutrients available for plant uptake, whereas logging removes a proportion of site nutrients. Pine forests often are regenerated using intensive site preparation and/or planting, often leading to major changes in floristic composition and structure.

Windthrow disturbance occurred in historical forests of the Central Sand Plains Ecological Landscape, but data on frequency and severity are lacking. Windthrow may have been relatively common in the swamp forests of tamarack and black spruce (*Picea mariana)* and in bottomland forests along rivers and streams where the shallow water table limited tree rooting depths. The wet-mesic eastern white pine-red maple forests that occupied the wetland-upland interface in some areas would also have been vulnerable to windthrow due to the high water table and shallow root zone (such an event knocked down a small acreage of this forest community in 2007). GLO Public Land Survey notes provide evidence of a large wind disturbance in the northwestern portion of the ecological landscape (southern Clark and eastern Jackson counties) at the time of the survey in the mid-19th century.

The extent and frequency of flood disturbance prior to Euro-American settlement is unknown. A few notable flood events occurred in this ecological landscape during early settlement before extensive modifications to the rivers took place. In June 1880, a huge flood occurred on the Wisconsin River after heavy rains, sweeping away structures in Wisconsin Rapids and killing one inhabitant. It is possible that river flows at this time could have already become flashy due to deforestation in surrounding watersheds, as eastern white pine had been harvested heavily since the 1830s. River velocity was significantly slowed over the next few decades by dam construction (Table 10.2), and later floods on this portion of the Wisconsin River were less severe (Taylor 1934). An October 1911 flood on the Black River, also attributed to heavy rains, broke through a dam at Hatfield as well as another dam 5 miles upstream and destroyed the business district of the town of Black River Falls. New dams were later constructed at Black River Falls and Hatfield.

Wetlands and sandy soils in this ecological landscape mitigate local flooding by rapidly absorbing precipitation; however, the low relief allows rivers and streams to flow out of their banks quite readily. Federal Emergency Management Agency maps show relatively wide floodplains around the Lemonweir River, Yellow River/Cranberry Creek (Juneau County), and the Wisconsin River except where impoundments or other water control structures are present (FEMA 2007). Modern data on flood events between 1996 and 2004 indicate that the Central Sand Plains Ecological Landscape has comparatively fewer floods than most of the state, although a higher amount of flooding was recorded in Wood County (NOAA 2005). It is likely that flooding has been reduced from historical levels due to construction of dams on rivers and streams. A reduction in flood pulses can disrupt processes of scouring and sediment deposition, which in turn affects seed dispersal and plant establishment in floodplains. Materials moved during floods are also important as food sources for aquatic organisms and as a nutrient source to the floodplain zone (Gergel et al. 2002).

Table 10.2. *Peak flows of water in the Wisconsin River, recorded by the Nekoosa-Edwards Paper Company at Nekoosa. Velocity was slowed by the construction of dams and other modifications of the Wisconsin River and its tributaries.*

Year	Water velocity (cu. ft./sec.)
1880	100,000
1900	70,000
1912	70,000
1914	56,400
1922	51,700
1924	61,000
1926	53,000
1928	45,000
1929	60,300

Source: Taylor (1934).

Forest Insects and Diseases

Central Sand Plains forests are dominated by oaks, conifers (pines, on the uplands), aspens, and swamp species (silver maple, green ash, river birch in the floodplains; tamarack and black spruce in the peatlands). Each of these forest species is associated with particular insects and diseases. There are a number of pest species that periodically affect forests in this ecological landscape.

Conifers, including red, eastern white, and jack pines, can be affected by annosum root rot, which is caused by the fungus *Heterobasidion annosum* and often occurs in plantations. Red pines are also subject to ***pocket mortality***, caused by a complex of insects and the fungal species *Leptographium terrebrantis* and *L. procerum*. Pocket mortality is more common in southern Wisconsin than in the north, possibly because trees are stressed by climate conditions that are less than ideal for this species. Red pine is also susceptible to Diplodia pine blight fungus (*Diplodia pinea*) and pine sawfly (*Neodiprion* spp., *Diprion* spp.). White pine blister rust is an introduced fungal disease caused by *Cronartium ribicola*, which is most severe in low-lying areas. Jack pine budworm is a native insect whose infestations can cause large-scale mortality of mature jack pine, setting up fuel conditions for catastrophic fire.

Gypsy moth (*Lymantria dispar*) is a nonnative insect, currently becoming established in this ecological landscape, which will periodically affect oak and aspen forests. Dry conditions in parts of this ecological landscape can facilitate gypsy moth population growth, leading to relatively faster rates of spread and more frequent outbreaks after establishment. The two-lined chestnut borer, *Agrilus bilineatus,* is a bark-boring insect that attacks oaks. Oak wilt is a vascular disease caused by the native fungus *Ceratocystis fagacearum*. Aspen can be impacted by forest tent caterpillar (*Malacosoma disstria*) and by *Phellinus* and *Hypoxylon* fungi.

Tamarack is attacked by a variety of insect pests that can occasionally kill large stands of tamarack forest. These include eastern larch beetle, larch sawfly, and the nonnative larch casebearer (*Coleophora laricella*).

The emerald ash borer (*Agrilus planipennis*) is not expected to have as great an impact on forest structure in the Central Sand Plains Ecological Landscape as in many other ecological landscapes in the state. Ash species are relatively minor components of the forest in the Central Sand Plains, making up less than 1% of RIV as indicated by FIA data (including trees of 1 inch or more in diameter), so most forests in this ecological landscape are not at high risk from emerald ash borer. However, green ash is common and is sometimes a canopy co-dominant in forested floodplains of the Black, Lemonweir, and Yellow rivers. Although Floodplain Forests do not comprise a large percentage of the forested land in the ecological landscape, they provide important breeding habitat for a number of rare species and maintain connectivity between forested sites within and between ecological landscapes.

More information about these diseases and insect pests of forest trees can be found at the Wisconsin DNR's forest health web page (Wisconsin DNR 2013a) and at the U.S. Forest Service Northeastern Area forest health and economics web page (USFS 2013).

Invasive Species

In forests, glossy buckthorn (*Rhamnus frangula*) is a serious problem in the southern and western parts of the ecological landscape, where it has become a dominant understory plant in several forest communities. Moneywort (*Lysimachia nummularia*) and creeping-Charlie (*Glechoma hederacea*) are common in bottomland hardwoods. Reed canary grass (*Phalaris arundinacea*) can be a serious problem in lowland hardwood forests in which the canopy has been opened. Gypsy moth and emerald ash borer could potentially become serious problems in the near future. Nonnative Eurasian honeysuckles (e.g., *Lonicera morrowii, L. tatarica*, and the hybrid *Lonicera* x *bella*), and garlic mustard (*Alliaria petiolata*) are becoming problems in some areas (e.g., at Mirror Lake State Park). These species may initially colonize disturbed areas and edges but, once established, can spread and continue to invade surrounding habitats in the absence of additional disturbance.

In grasslands, spotted knapweed is now a dominant plant in some disturbed sandy areas (e.g., it is abundant in the median strip and along the shoulders of Interstate 94, which runs along the western border of the Central Sand Plains). Leafy spurge and cypress spurge occur on a variety of sandy upland sites, including natural communities, old fields, rights-of-way, and surrogate grasslands (somewhat open dry forests are also somewhat vulnerable to infestation by these species). They are still locally distributed as of 2008 but will likely spread if not controlled. Control measures should be prioritized in and around natural communities that are otherwise in good condition, in vegetation types that are especially vulnerable to significant loss of native plant and animal diversity (e.g., barrens remnants or where populations of rare native species occur along rights-of-way), and at large sites of importance to sensitive animals but which are not yet overrun. Ecologically important sites should be monitored periodically for the presence of invasives. Control efforts are likely to be much more cost effective and successful if implemented when invasive species are first detected.

Invasive Eurasian honeysuckles have formed a nearly impenetrable layer under a canopy of oak and jack pine at Mirror Lake State Park. Reproduction of these trees under such conditions is impossible. Juneau County. Photo by Eric Epstein, Wisconsin DNR.

In aquatic and wetland ecosystems, the primary problem species include reed canary grass, glossy buckthorn, purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), Eurasian water-milfoil (*Myriophyllum spicatum*), curly pondweed (*Potamogeton crispus*), common carp (*Cyprinus carpio*), and rusty crayfish (*Orconectes rusticus*).

There are many more nonnative species present in the ecological landscape, but their potential effects are less certain at this time. For more information about invasive species in Wisconsin, see the Wisconsin DNR's invasive species web page (Wisconsin DNR 2013b).

Land Use Impacts

Historical Impacts. During and before recorded history, humans have been a driving force affecting ecosystem composition, structure, and function in this ecological landscape. In the 20th century, widespread drainage projects as well as the construction of dams and impoundments altered the physical environment with cascading effects on vegetation, wildlife, and natural disturbances. Fire suppression activities have reduced fire frequency and intensity while increasing fuel loads. This has led to changes in vegetation composition and structure, patch sizes, heterogeneity, and habitat connectivity. Fire suppression has allowed early successional habitats such as Pine and Oak Barrens to succeed to dense forests of oak or pine. The natural firebreaks present in the landscape before Euro-American settlement have been vastly modified by wetland drainage in some areas and the creation of impoundments in others.

Current Impacts. Current disturbances in the ecological landscape are largely due to human activities, primarily agriculture, cranberry production, home development, and timber harvest**.** Human disturbance also includes the long-term conversion of land to roads, buildings, and utility corridors. Impoundments, created in the past as a restoration activity to increase waterfowl habitat, often flooded sedge meadows, peatlands, or other natural communities. Because of the sterile soils and low productivity characteristic of much of the Central Sand Plains, these impoundments have not historically been very productive for waterfowl (Nelson 1978). Finally, disturbances result from logging and recreational pursuits such as ATV use.

A major difference between current and historical disturbances is that many of today's impacts are multiple (sometimes simultaneous), pervasive, and affect many parts of the landscape almost constantly. Historically, some landscapes (the vast forests of Wisconsin's North Woods would be an

example) existed in a quasi steady-state condition, where disturbances affected different parts of the area at intervals, leaving other portions undisturbed for relatively long or variable time periods.

In many parts of the Central Sand Plains Ecological Landscape, however, disturbances such as periodic wildfire were frequent, maintaining large areas in an open condition. Today the disturbance frequency for natural vegetation has been almost reversed. As a result, open areas have been greatly diminished while dense forests have grown up in places formerly affected by frequent fire. Another major difference between current and historical conditions is that many of the present disturbances had not occurred prior to Euro-American settlement. Dams, drainage ditches, dikes, inputs of nutrients and sediments, groundwater withdrawals, replacement of native vegetation with a few crops, use of herbicides and pesticides, and the introduction of invasive species have altered or even replaced formerly important natural disturbance regimes (by affecting magnitude, severity, frequency, timing, and recovery potential).

Many of central Wisconsin's abundant wetlands have been extensively altered by ditches and dikes. Partial restoration has occurred at Dike 17 State Wildlife Area. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Land recently cleared for the construction of new cranberry beds in southern Adams County. Photo by Eric Epstein, Wisconsin DNR.

In addition to direct impacts, human land uses and land use patterns have indirectly affected ecosystem composition, structure, and function by altering natural disturbance regimes. For example, changes in the age structure, patch size, and context of forests may make stands more or less vulnerable to wind disturbance. Fragmentation, isolation, and simplification of stands, whether forest, savanna, prairie, or bog, have changed suitability of any given patch for native plants and animals. Dams and ditches have altered functional dynamics of many wetland communities. Dams restrict the movement of species, reduce flow rates, and in some cases, lead to increased water temperatures. Rivers and streams become lakes. Fires are now carefully controlled and cannot be allowed to run unchecked across large areas. Recent changes in land use and land cover have created new fire breaks and eliminated some of those that existed prior to Euro-American settlement.

Hydrological Disruption. A network of small canals was constructed to facilitate the movement of pine logs in remote, lightly roaded eastern Jackson County. Vestiges of these canals still exist, and some of them still hold water. Eswein (1995) discussed and mapped the extensive network of canals, tramways, and logging railroads constructed in the "***Great Swamp of Central Wisconsin***" during the 1800s.

Early in the 20th century, there were many attempts to drain the wetlands of the Central Sands region of Wisconsin. The high water table, low fertility, and frequent growing season frosts made agriculture in many areas of the ecological landscape unsuccessful, especially west of the Wisconsin River. The agricultural focus in that area has shifted to commercial cranberry production, where the intent is no longer to get rid of the water but rather to control it to facilitate the commercial production of cranberries. The impoundments also serve as reservoirs to provide a means of preventing growing season frost damage**.** The National Weather Service issues local frost warnings for the "cranberry bogs," and the

At many locations, the hydrology of central Wisconsin's peatlands has been altered by extesive ditch and dike construction. Wood County. Photo courtesy of the National Agricultural Imagery Program.

The Petenwell Flowage (Lake Petenwell) forms Wisconsin's second largest inland lake. It was created in 1948 with the construction of a dam across the Wisconsin River near Necedah. Photo by Wisconsin DNR staff.

growers spray the cranberry plants with water on summer nights when frosts have been forecast to avoid losing the fruits or flowers to frost. When impoundments are created, they often flood large areas of wetlands, including tamarack swamps, bogs and fens, shrub swamps, sedge meadows, and other habitats (see the "Hydrology" section of this chapter for more discussion of impoundments and cranberry production). In recent years, some new cranberry beds have been developed on uplands. Pumps are used to flood the sites when water is needed.

Large parts of the Central Sand Plains in southern Wood, southwestern Portage, eastern Jackson, northeastern Monroe, western Juneau, and scattered locations in Adams counties have relatively few natural stream courses left due to extensive channelization, ditching, and impoundment construction. These alterations have caused major disruptions to stream and wetland hydrology.

Agriculture. Many lands east of the Yellow and Wisconsin rivers were drained (these formerly supported conifer swamp, bog, sedge meadow, and fen wetland vegetation) and now support extensive agriculture, much of it dependent on center pivot irrigation. When the first Juneau County Soil Survey was conducted in 1914 (WGNHS 1914), some ditches were already present in the peatlands, but drainage was described as "not sufficiently thorough," and ditch deepening was recommended. Twenty years later, the 1934 Wisconsin Land Economic Inventory described how ditching had lowered the water table and had "ruined the sand peat plain for cranberries, sphagnum, and marsh hay" (Bordner et al. 1934). Crops grown here now include potatoes, corn, soybeans, and various small grains. Land that is not under cultivation is or has been used for grazing cattle, and these

Recent intensive agricultural development and center pivot irrigation west of the Wisconsin River. Note habitat fragmentation and algae blooms in the river due to nutrient-laden agricultural runoff. Photo courtesy of the National Agricultural Imagery Program.

Center pivot sprinkler system in a field planted with corn. Photo courtesy of Missouri Department of Natural Resources.

areas now comprise one of the state's largest grassland complexes (though these grasslands are composed mostly of nonnative species). Many grassland birds find suitable nesting habitat in these "surrogate grasslands." See the "Fauna" section of this chapter for details.

A large quantity of groundwater is being withdrawn for irrigation, industry, and municipal uses in the eastern part of the ecological landscape. Hydrologic modeling has led researchers to conclude that this rate of groundwater withdrawal is contributing to the observed lowering of local water tables, stream flows, and seepage lake levels (Kraft and Mechenich 2010). Although data are lacking, this could have long-term impacts on wetlands, rivers, streams, and lakes. In addition, recently constructed ditches that are large and deep could "puncture" the relatively impermeable layers of fine materials underlying the sandy lakebed/outwash sediments and lead to a general drying of the wetlands and an ultimate loss of wetland habitat in the ecological landscape.

Groundwater contamination via agricultural use has also been an issue in the intensively cultivated portions of the ecological landscape south of Stevens Point (including the Buena Vista and Leola Marsh Wildlife Areas). Because of the highly permeable sandy soils, agricultural chemicals quickly leach into the groundwater. Historically, Paraquat, Aldicarb, and, more recently, Atrazine have been identified as problems in the Central Sand Plains (Portage County Government 2008). In the 1970s, there was concern over impacts to nontarget organisms and habitats from pesticide drift due to the large areas of croplands being sprayed from the air.

The groundwater contamination susceptibility rankings indicate that the eastern and southern portions of the ecological landscape (where agricultural land uses are most intensive) are quite vulnerable to groundwater pollution as compared with other areas of the Central Sand Plains and elsewhere in Wisconsin. This area of highest susceptibility encompasses watersheds within the Central Wisconsin and Lower Wisconsin River basins. Only the watersheds of the Central Sand Hills Ecological Landscape to the east and the southernmost portion of the Forest Transition Ecological Landscape have comparable groundwater pollution susceptibility rankings. Because contaminated groundwater can enter streams and lakes at recharges areas, protecting the biological diversity of lakes and streams from the negative impacts of pesticides here will require coordination with a host of groundwater protection agencies and other interests.

Forest Management. The western portion of the ecological landscape contains some of the largest and least fragmented blocks of forest in the southern half of the state. Much of the publicly owned forest is used to produce pulp, sawtimber, and habitat for selected wildlife species, usually game species. Conversion of "natural" forests, barrens, and sand prairies to pine plantations has been common in some areas. The use of herbicides to aid in the establishment of these plantations can reduce or eliminate native plants and some of the animals dependent on native flora. Such practices may also pose a threat of groundwater contamination in areas with high water tables.

Forest management should be planned and designed to maintain patch sizes, age classes, and the ecological connections necessary to maintain or restore the full complement of native animals and avoid further fragmentation, isolation, and simplification of habitats. Where "forests" are now managed on sites that formerly supported pine or oak barrens, management plans and methods should be evaluated and developed carefully to avoid further reducing the amount of these globally rare natural communities and the many rare species now dependent upon them.

Opportunities for the designation or management of old-growth and older forest are best in the extensive floodplains of the larger rivers, on the bluffs and terraces adjoining some of these rivers (e.g., along the Black River and some of its tributaries south of Lake Arbutus, along the East Fork of the Black, the Yellow, and the Lemonweir), in and on the margins of large forested peatlands, and within some of the larger blocks of upland oak or pine forest where site conditions are more favorable for longer-lived tree species.

Mossing. The harvest of sphagnum mosses from peatlands for commercial purposes on both public and private lands has taken place in the western part of the ecological landscape since the late 19th century (Esposito 2000). Moss was initially gathered for bandaging wounds but now is mostly used in the floral industry for packing material and mulch and in decorative floral and dried plant arrangements. Originally, moss harvest was conducted by hand, with rakes, but in recent years the harvest has become mechanized. On state lands, "mossing meadows" may be harvested once each seven to nine years; moss is usually removed in early summer. On the Black River State Forest, about 70 acres of moss are harvested annually on a rotating basis, out of about 500 acres open to mossing (Wisconsin DNR 2010a). On the Jackson County Forest, moss is harvested from 60 to 80 acres per year. An unknown number of acres of private bogs are also harvested for moss each year in the Central Sand Plains Ecological Landscape.

There has been little research in our area on the ecological effects of moss harvesting, but a study conducted in east-central Minnesota concluded that recovery of moss biomass after a winter harvest would take more than 20 years (Elling and Knighton 1984). Numerous studies have shown that growth rates differ among sites depending on canopy cover of shrubs or sedges, nutrient supply, water table levels, and temperature (Gerdol 1995, Whinam and Buxton 1997). This variability makes it difficult to extrapolate growth rates to the Central Sand Plains from other locations.

Recently, Australia developed guidelines for sustainably harvesting sphagnum mosses, including recommendations to harvest by hand, retaining 30% of sphagnum on site, and allowing 5–10 years between harvests (Australian Department of the Environment and Water Resources 2007; Tasmanian Department of Primary Industries, Parks, Water, and

The commercial harvest of living sphagnum ("peat") moss from central Wisconsin wetlands has been occurring since the late 1800s. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Environment 2006). Scotland has recently advised that gathering in bogs is not a sustainable practice, and mosses can now only be collected by hand from pine plantations. These guidelines call for 50% of sphagnum to be left unharvested and for five years between harvests (Forestry Commission Scotland 2007).

In addition to uncertainty about the rate of sphagnum replenishment, there are concerns about effects on nesting birds. Besides songbirds, this practice could also affect Sandhill Crane, American Bittern, Northern Harrier, Yellow Rail (*Coturnicops noveboracensis*), Wilson's Snipe (*Gallinago delicta*), and various waterfowl species, among others. Negative impacts on invertebrates, as well as plants incidentally taken along with sphagnum, are also of concern. At least one rare bird, the Wisconsin Threatened Henslow's Sparrow, has been recorded during the breeding season in mossed peatlands. When mossing occurs during the nesting season, nests are destroyed. Mossed areas are unsuitable for nesting for at least several years afterward because Henslows' Sparrows require a litter layer in which to construct their nests. The time at which a site again becomes suitable for nesting following moss harvest is not known nor has information been collected on how much habitat at a site should be left unharvested to accommodate Henslow's Sparrows or other species.

Several very rare invertebrates occur in the large open peatlands potentially subject to mossing (e.g., the ringed boghaunter dragonfly). Eastern massasauga rattlesnakes historically used the open peatlands in this ecological landscape. In recent decades, several large, hydrologically intact peatlands were converted to cranberry beds and/or impoundments (e.g., "Rattlesnake Marsh" in eastern Jackson County), with a resulting loss of habitat for some of the peatland inhabitants. Washburn Marsh State Natural Area (note that this is not a marsh—it's a large acid peatland) on the Black River State Forest was established in part to provide a reference area against which to measure the effects of mossing, but few data have been collected thus far. Both mossed and unmossed areas occur within Washburn Marsh.

Several rare plants occur in these same habitats. Some, but not all, may be able to take advantage of certain kinds of disturbance, but information is almost completely lacking on the extent, amount, and timing of moss harvest that would allow for continued persistence of a species at a given site.

Managers of public lands need to know which of the many species of sphagnum are being harvested and whether the "rotation" of seven to nine years applies to a single species, a subset of the sphagnum species present, or to all of the sphagnum species present. Recovery rates are likely to vary among the various species of moss present. Impacts on other taxa are generally unknown, although all living plants are removed from the mossed areas, bird nests are destroyed, and habitat for other animals is altered. Concerns over potential biological impacts (and on the costs of administering sales relative to the return) prompted property managers to halt moss harvest at Meadow Valley State Wildlife Area around 1990 (Esposito 2000). Mossing is also not allowed at Necedah National Wildlife Refuge.

Living sphagnum moss has been harvested commercially from this open peatland in eastern Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Washburn Marsh, Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Fragmentation. An increase in more intensive agriculture and additional residential development, along with tree planting, can result in fragmentation of the extensive open grasslands needed by many obligate open country species, such as the Greater Prairie-Chicken, Upland Sandpiper, Northern Harrier, and Short-eared Owl. Habitat fragmentation as a result of land use practices is most pronounced east of the Yellow River where extensive, intensively used agricultural lands are now intermixed with small woodlots and pastures. The western portion of this ecological landscape has some of the largest blocks of upland forest and wetland habitats remaining in the southern half of Wisconsin.

Fragmentation and stand isolation are important management challenges to address in all forest types in order to accommodate the needs of area- and edge-sensitive species and avoid increasing the vulnerability of several important forest types to excessive wind damage. The latter factor can be especially important in forests composed of shallow-rooted species (pines, tamarack, black spruce) or on sites where a high water table prevents plant roots from penetrating deeply.

Opportunities for large-scale restoration of Pine Barrens and/or Oak Barrens are good in this ecological landscape and could be very compatible with forest management, especially for early successional types, on appropriate sites. Some of the large-scale barrens restoration projects have recently incorporated patches of scattered large trees into their management scenarios. This can provide habitat for species that do not thrive in either the more open barrens, in which trees are reduced to grubs or sprouts only a few meters high, or in dense forests. This design can also reduce or eliminate the hard edge that is often present at the interface of managed barrens and forests.

Residential Development. Dispersed residential development has occurred in some parts of the ecological landscape. Additional development has occurred around the shores of large flowages. Dispersed developments can be subject to increased fire risk in this fire prone landscape. Such development also decreases prescribed burn opportunities and results in habitat fragmentation and loss of habitat connectivity. In some areas, destruction of rare sand prairie and barrens habitats has occurred because of residential development or associated infrastructure such as roads and utility lines. Managed differently, some of these rights-of-way could serve as site connectors and reduce isolation.

Military Training. Military training occurs in this area and has involved low level flights by jets that may disturb wildlife. Also, the Air National Guard maintains the "Hardwood Gunnery Range," which includes several thousand acres in northern Juneau County. Practice bombing and strafing occur there and sometimes result in fires. These periodic fires may help to maintain some of the fire-dependent communities on this site, but more detailed survey information is needed to better understand the impacts.

Management Opportunities for Important Ecological Features of the Central Sand Plains Ecological Landscape

Natural communities, waterbodies, and other significant habitats for native plants and animals have been grouped together as "ecological features" and identified as management opportunities when they

- occur together in close proximity, especially in repeatable patterns representative of a particular ecological landscape or group of ecological landscapes;
- offer compositional, structural, and functional attributes that are important for a variety of reasons and that may not necessarily be represented in a single stand or single community type;
- represent outstanding examples of natural features characteristic of a given ecological landscape;
- are adapted to and somewhat dependent on similar disturbance regimes;
- share hydrological linkage;
- increase the effective conservation area of a planning area or management unit, reduce excessive edge or other negative impacts, and/or connect otherwise isolated patches of similar habitat;
- potentially increase ecological viability when environmental or land use changes occur by including environmental gradients and connectivity among other important planning and management considerations;
- accommodate species needing large areas or those requiring more than one habitat;
- add habitat diversity that would otherwise not be present or maintained; and
- provide economies of scale for land and water managers.

A site's conservation potential may go unrecognized and unrealized when individual stands and habitat patches are managed as stand-alone, independent entities. A landscape-scale approach that considers the context and history of an area, along with the types of communities, habitats, and species that are present, may provide the most benefits over the longest period of time. This does not imply that all of the communities and habitats associated with a given opportunity should be managed in the same way, at the same time, or at the same scale. Instead, we suggest that planning and management efforts incorporate broader management consideration and address the variety of scales and structures approximating the range of natural variability in an ecological landscape—especially those that are missing, declining, or at the greatest risk of disappearing over time.

Both ecological and socioeconomic factors were considered when determining management opportunities. Integrating ecosystem management with socioeconomic activities can result in efficiencies in the use of land, tax revenues, and private capital. This type of integration can also help to generate broader and deeper support for sustainable ecosystem management. Statewide integrated opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book.

Significant ecological management opportunities that have been identified for the Central Sand Plains Ecological Landscape include

- extensive forests: pine, oak, mixed;
- Oak and Pine Barrens;
- rivers and streams, floodplains, riverine lakes, riparian corridors;

- peatlands: forested and nonforested;
- surrogate grasslands;
- geological features (sandstone buttes, pinnacles, gorges, cliffs);
- miscellaneous rare communities and habitats; and
- scattered rare plant and animal populations.

Natural communities, community complexes, and important habitats for which there are management opportunities in this ecological landscape are listed in Table 10.3. Examples of some locations where these important ecological places may be found within the ecological landscape are shown on the map entitled "Ecologically Significant Places of the Central Sand Plains Ecological Landscape" in Appendix 10.K.

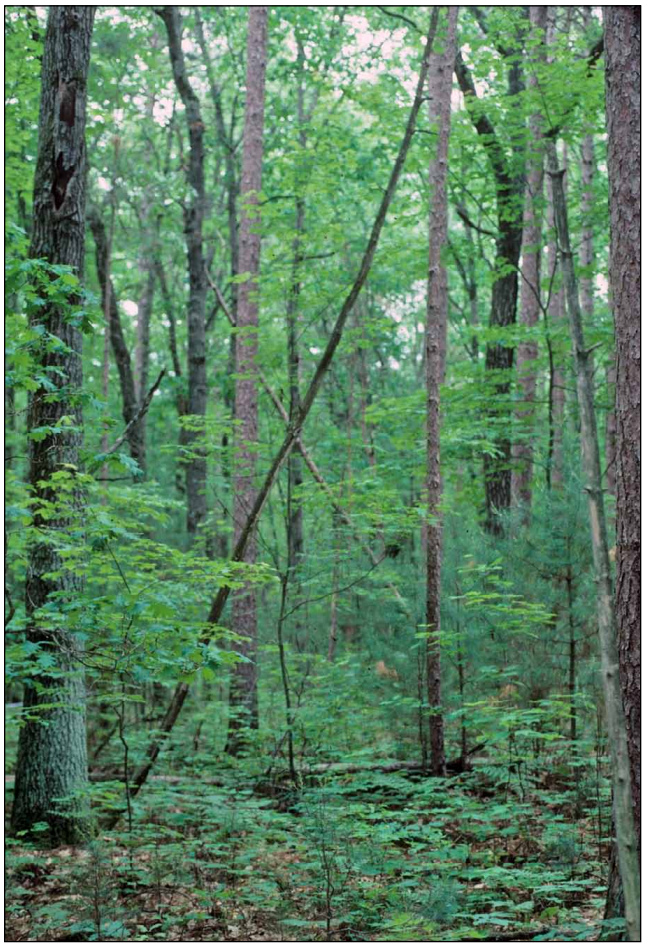
Outstanding Ecological Opportunities in the Central Sand Plains Ecological Landscape

- The Central Sand Plains is more forested and less developed than any other southern Wisconsin ecological landscape.
- Extensive forests of oak, pine, and aspen now occur west of the Yellow River.
- The large public land base west of the Yellow River offers an opportunity to manage native ecosystems at large scales. Restoration and management of globally rare oak and pine barrens communities is a highly significant opportunity here.
- Large river systems provide habitat and travel corridors for species of management concern.
- River corridors provide a means of maintaining habitat connectivity between sites in the Central Sand Plains and with sites in ecological landscapes to the north, south, and west.
- Boggy peatlands and associated species remain common and extensive.
- Extensive "surrogate grasslands" occur to the east of the Wisconsin River, and these support many rare and declining grassland birds of management concern.
- There are excellent opportunities to protect rare natural communities and successional, and developmental stages. Some of these can be planned and managed at large scales.
- Bedrock features include unusual sandstone buttes, pinnacles, and gorges, which support habitat specialists and distinctive assemblages of plants and animals.
- The use of prescribed fire is possible at multiple scales and would have many benefits, from restoring habitat needed by rare species to increasing public safety by reducing the risk of uncontrolled wildfire.

Extensive Forests: Pine, Oak, Mixed

When compared with other ecological landscapes in southern Wisconsin, the western parts of the Central Sand Plains Ecological Landscape contain the most extensive areas of relatively contiguous upland forest. These forests tend to be dry, are composed mostly of pines and oaks, and may occur in homogeneous even-aged stands or in various mixtures of species, sizes, and age classes. Aspens are scattered throughout the ecological landscape but are most important in the northwest. On glacial lakebed and outwash landforms, the terrain is nearly level and the water table is often high. Areas of dry forest are interspersed in complex patterns with peatlands, including some that are very large. In areas underlain by ridges of sandstone bedrock, the terrain can be rugged and steeply rolling. Site conditions on such terrain vary from dry to dry-mesic, and there may be considerable variation in forest composition and structure. The extensive forests afford protection to streams and wetlands at the local site and watershed levels.

Historically, fire was the major disturbance factor influencing the upland forests of the Central Sand Plains Ecological



Northern Dry-mesic Forest, with a canopy of eastern white pine, red pine, black oak, white oak, and red maple. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Table 10.3. *Natural communities, aquatic features, and other selected habitats associated with each ecological feature within the Central Sand Plains Ecological Landscape.*

Ecological features[a]	Natural communities,[b] aquatic features, and other selected habitats
Extensive forests of oak and pine	Central Sands Pine-Oak Forest Northern Dry Forest Northern Dry-mesic Forest Southern Dry Forest Southern Dry-mesic Forest Southern Mesic Forest Oak Woodland Forested Seep
Pine and Oak Barrens	Oak Barrens Pine Barrens Sand Barrens Sand Prairie
River and stream corridors	Floodplain Forest Hardwood Swamp Southern Mesic Forest Alder Thicket Shrub-carr Northern Sedge Meadow Southern Sedge Meadow Emergent Marsh Coldwater Stream Warmwater River Warmwater Stream
Peatlands	Northern Wet Forest Black Spruce Swamp Tamarack (Poor) Swamp Northern Sedge Sedge Open Bog Central Poor Fen
Surrogate grasslands	Conservation Reserve Program (CRP) lands Conservation Reserve Enhancement Program (CREP) lands Fallow Fields Pastures
Miscellaneous rare communities	White Pine-Red Maple Swamp Hemlock Relict Pine Relict Sand Prairie Coastal Plain Marsh Bedrock Glade Dry Cliff Moist Cliff
Unusual geological features	Unglaciated sandstone pillars, mesas, and gorges

[a]An "ecological feature" is a natural community or group of natural communities or other significant habitats that occur in close proximity and may be affected by similar natural disturbances or interdependent in some other way. Ecological features were defined as management opportunities because individual natural communities often occur as part of a continuum (e.g., prairie to savanna to woodland or marsh to meadow to shrub swamp to wet forest) or characteristically occur within a group of interacting community types (e.g., lakes within a forested matrix) that for some purposes can more effectively be planned and managed together rather than as separate entities. This does not imply that management actions for the individual communities or habitats are the same.

[b]See Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book for definitions of natural community types.

Landscape. Fire suppression policies have now been in place for over 70 years. Along with new disturbances such as logging and grazing, this has altered the abundance, composition, and structure of forests throughout the Central Sand Plains.

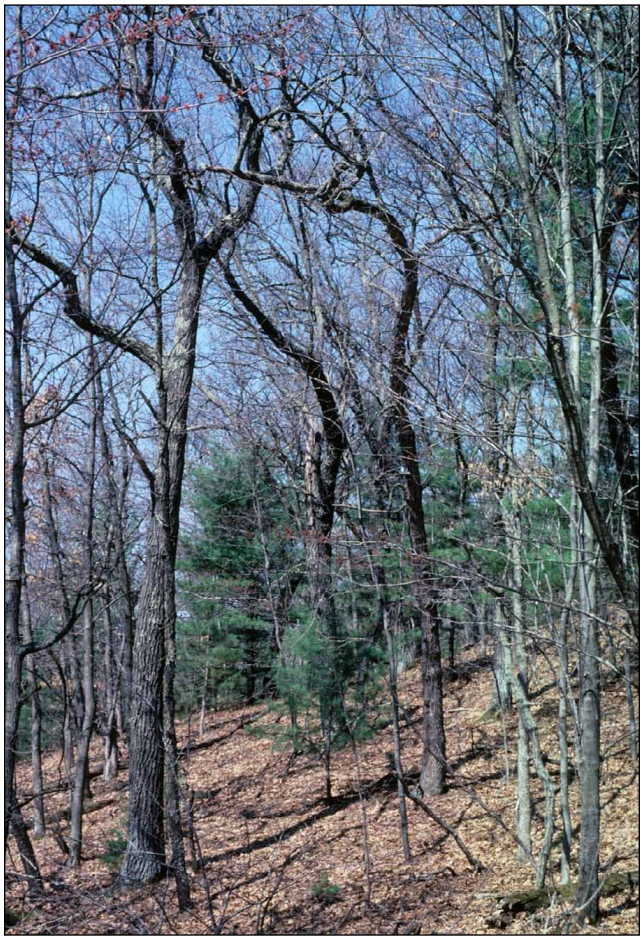
In part because they are extensive, the forests of this ecological landscape can accommodate the vast majority of forest inhabitants native to this region, including wide-ranging and area-sensitive species and many habitat specialists. At larger scales, management opportunities are best for species adapted to drier forests dominated by either oaks or pines, in many mixtures. But there are also good opportunities to manage for forests and wildlife associated with wet conditions.

The larger blocks of relatively unbroken forest in the western part of the ecological landscape occur on the Black River State Forest and the Clark and Jackson county forests. Sites in Adams, Juneau, and Wood counties offer opportunities to manage upland forests at more moderate scales. On the public lands, management has generally been planned and conducted on a stand-by-stand basis, which can lead to fragmentation and the elimination of large relatively homogeneous habitat patches. Most forests, due to their origins and past management histories, lack important structural elements such as old trees, large standing snags, and large coarse woody debris.

On the dry sites, the most important cover types include jack pine, black oak, and white oak. Red pine is now abundant due to extensive planting, and the acreage of red pine plantations has increased dramatically in recent years, often been at the expense of jack pine and "scrub oak" (which, in central Wisconsin, may include black oak, northern pin oak, bur oak, or white oak). Decades of fire suppression have resulted in dry forests that are very densely stocked. On some sites, eastern white pine is now an abundant understory species, creating heavy shade that selects against understory plants that demand higher light levels. This can be a serious problem when restoration of barrens and management of important cover types such as jack pine or scrub oak are the management goals. Eastern white pine on dry sites in the Central Sand Plains may have neither the ecological or commercial potential it demonstrates on loamier sites farther north, such as the Northern Highland Ecological Landscape.

In the Central Sand Plains, many of the dry sites now succeeding to eastern white pine historically supported either barrens vegetation or short-lived stands of jack pine of highly variable density. These cover types are now seriously diminished because of fire suppression, deliberate type conversions, or successional processes. That being said, there are many appropriate upland sites for eastern white pine and, more rarely, for natural red pine. Examples include portions of the Clark County Forest, the Overmeyer Hills in southern Jackson County, areas east of the Black River State Forest in Jackson County (an area that supported a significant pinery during the late 19th century), on bluffs bordering some of the major river corridors, and at scattered locations elsewhere.

This 40-year-old stand of jack pine was "thinned" by an infestation of jack pine budworm, allowing the development of a layer of sapling jack pine. Sites such as this one do not have high potential for commercial forest management due to low fertility, combined with severe droughts in the sandy soils. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.



Extensive forest of black and white oaks, with eastern white pine in the understory. Overmeyer Hills, Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Eastern white pine also occurs on wet-mesic sites in the Central Sand Plains Ecological Landscape, and it is not desirable to lump such stands with upland forests now dominated by, or succeeding to, eastern white pine. Management challenges and considerations are very different because of hydrology, fragile soils, invasive species problems, and biodiversity values.

Key forest management challenges overall include the avoidance of fragmentation, isolation, and simplification. Currently there is an under-representation of large patch sizes (for both younger and older forest), intact older forest, and certain cover types (e.g., jack pine, natural red pine). The needs of habitat specialists and connections with other landscape features such as floodplains and conifer swamps should be considered and addressed by planners and managers early in the planning process for their respective jurisdictions.

Some apparently recent successional changes, such as the development of dense understories of eastern white pine on dry sites beneath canopies of oaks or other pine species, are not desirable everywhere. This is especially important on those sites that formerly supported communities such as barrens, open oak woodlands, or short-lived xeric forests of variable density with scattered openings. Because eastern white pine is so long-lived and casts heavy shade, it can ultimately exclude light-demanding species.

Managing for oak beyond commercial rotation ages is highly desirable to retain key forest structural elements and accommodate habitat needs of certain species (e.g., some of the forest raptors, Cerulean Warbler). Dry-mesic sites capable of supporting large northern red and white oaks are best suited to this, but some stands of black and white oak might also be considered.

Infestations of gypsy moth may occur here, especially in the drier oak and aspen forests. For related planning considerations, see Wisconsin DNR's *Gypsy Moth Silvicultural Guidelines for Wisconsin* (Brooks and Hall 1997). Deer and exotic earthworms may be relatively lesser threats in the sandy, nutrient-poor forests of the Central Sand Plains compared to ecological landscapes containing more mesic, nutrient-rich forests.

Management Opportunities, Needs, and Actions

- Maintain large patches of contiguous forest, including early successional forest types dominated by species such as jack pine and scrub oak that are important in the Central Sand Plains. Maintenance of forests composed of and dominated by species such as jack pine, black oak, and northern pin oak is important here and merits additional attention from managers of public lands and from those who advise private landowners. Dry forests composed of these species and their associates provide excellent habitat for many wildlife species, including game animals, and a number of rare or declining species such as Connecticut Warbler, Red Crossbill, Eastern Whip-poor-will, and Brown Thrasher.
- The recent (2007) discovery of the U.S. Endangered Kirtland's Warbler breeding in this ecological landscape affords an opportunity to actively manage jack pine forest habitat that will potentially maintain viable populations of this critically imperiled bird.
- Integrate the management of dry forests and barrens where feasible and most appropriate. Several sites offer opportunities to do this. Examples occur on the sandy flats along Morrison and Robinson creeks in eastern Jackson County, where it is possible to integrate management of dry jack pine and oak forests with barrens restoration activities by aggregating harvest units to create larger open areas where they are needed to provide for area-sensitive species and to periodically connect otherwise isolated habitat patches (potentially providing for area-sensitive forest inhabitants as well as conifer specialists).
- Several large dry forest-barrens complexes should be identified and considered for landscape-scale management in the Central Sand Plains. Solving jurisdictional complexities will be challenging, but opportunities to do this in other southern Wisconsin landscapes are nil.
- Some dry sites now succeeding to eastern white pine dominance historically supported either barrens vegetation, short-lived stands of jack pine, or mixed stands of pine (jack or red) and oak (black, white, northern pin) of highly variable density. Restoration of sites such as this to pine or oak barrens or to forests with relatively short rotation periods (e.g., jack pine) is an appropriate and important consideration for planning and management.
- Consider long-term retention of openings on forested sites that formerly supported Oak or Pine Barrens or for forest types such as jack pine or black oak that historically experienced frequent catastrophic disturbance due to wildfires. Such remnant barrens may have high potential to maintain sensitive native plants and animals that will

White and black oak forest north of Overmeyer Hills. Black River State Forest. Photo by Eric Epstein, Wisconsin DNR.

be suppressed and eventually disappear under prolonged periods of high canopy closure. Openings that maintain native plants and animals adapted to open conditions can serve as important refugia for barrens-associated plants and animals that may not persist through an entire commercial rotation, i.e., where the management objective for the stand is now to maximize fiber production by developing and encouraging a densely stocked forest. In stands managed primarily for timber products, maintaining these openings becomes an important management consideration if the continued loss of sensitive native plants and animals is to be minimized or avoided. This consideration does not apply to lowland forests or to more mesic upland forest cover types such as maple-basswood, white pine-red pine, northern red oak-white oak, or the various mixtures of eastern white pine-red pine-white oak-northern red oak that occur in various locations in this ecological landscape. These are forests capable of supporting sensitive forest interior species, including forest raptors, and should be managed accordingly.

- The development of tools that would allow managers to recognize patches containing remnant barrens flora or support rare animals should be a priority. These tools could result in increased protection of sensitive elements during management activities such as timber harvest, and their use would inform both annual and long range property planning efforts. This is one of several important forest certification considerations in the Central Sand Plains. (The term "***High Conservation Value Forest***" does not apply only to forest vegetation.)
- Large, topographically complex sites may include cool and moist as well as hot and dry exposures; may contain pockets of more productive soils and level as well as steeply sloping lands, springs, and seepages or bedrock exposures; and may as a result support more variable vegetation (including patches of dry-mesic or even wet-mesic forest that will potentially offer the best opportunities to provide stands of old forest and/or old-growth forest in this generally drought-prone landscape). When planning considers site potential beyond the scale of the individual stands delineated, it may be possible to increase effective forest patch size (leave or create large patches), avoid fragmentation and the development of excessive amounts of habitat edge (context and infrastructure development), and provide more varied and secure habitat for area-sensitive forest animals by embedding such stands within more extensive areas of dry forest.
- Opportunities to designate and manage old forest and old-growth forest should be pursued where appropriate. There are opportunities via active planning, restoration, program integration, and the exercise of patience to allow for the development of missing old-growth characteristics in the dry and dry-mesic forests of the Central Sand Plains. Many of these forests do not provide large habitat patches (including relatively large forested areas with high canopy closure), and most lack important structural features such as large trees, standing snags, and large coarse woody debris. These missing attributes can be partially restored by modifying management prescriptions at the stand level but really need to be considered and discussed during property- or multi-property–level planning. Not every site will offer equivalent opportunities, and some sites will be better suited for the management of more extensive areas of younger forests (scrub oak, jack pine, aspen) and barrens.
- Until recently, the implementation of "big tree silviculture" guidelines was policy on all State Forest land. This was done primarily to meet perceived aesthetic desires of the public, but it did have several associated ecological benefits, including the retention of large, though often widely scattered, trees. State Forest master plans now designate management objectives and prescriptions for particular areas using various land management designations. For information on the retention of biological legacies such as large diameter trees, snags, and coarse woody debris, see Chapter 24, "Tree Marking and Retention Guidelines," in the DNR's *Silviculture Handbook* (Wisconsin DNR 2010b).
- Big tree silviculture was not (and is not) a substitute for forest interior management or the restoration and management of old-growth forest. Guidelines for incorporating old-growth forest into management plans are now available for several important cover types (e.g., northern hardwoods, bottomland hardwoods) in the Wisconsin DNR's *Old-growth and Old Forests Handbook,* and chapters on additional forest types are in preparation (Wisconsin DNR 2006a). Although there are now opportunities to provide for older forests on state lands, it must be realized that the policy to apply big tree silviculture guidelines to State Forest lands was replaced by *Old-growth and Old Forests Handbook* guidelines. The impacts of this change should be monitored and, should it prove necessary, a new policy developed that better addresses habitat issues.
- In upland situations, dry-mesic sites may offer some of the better opportunities for the establishment and maintenance of old forest and old-growth forest. Dry-mesic sites, though less common here than dry sites, have the potential to support stands composed of long-lived species such as eastern white pine, northern red oak, red pine, and white oak. The development of older forests composed of these and several other species is possible at locations on the Black River State Forest, in several state parks, at various sites along some of the ecological landscape's river corridors, and probably elsewhere.
- Embed stands of older forest within more extensive areas of (managed) dry forest, and ensure that management of the surrounding forest avoids the creation of excess forest

edge and increases the forest's effective area so that fragmentation and isolation of forest habitats is avoided. There is potential for embedding mature dry-mesic hardwood stands within much more extensive areas of other forest communities, such as dry pine-oak forests, or adjacent to forested floodplains. Both Southern Dry-mesic Forest and Northern Dry-mesic Forest communities have good old-growth management potential and may be strong candidates for alternative management designations such as extended rotation, managed old forest, or old-growth reserve. These are options to consider, and alternative management designations may provide a means of meeting desired or required management objectives on certain properties or in specific situations and of providing habitat for those species associated with older forests.

- There is a need to plan at large scales, broaden ecological perspectives and benefits, and coordinate management across program and jurisdictional boundaries. Retrofitting integrated resource management considerations after the fact is difficult and less likely to be successful than an investment up front. The benefits of planning at least some aspects of forest management at large scales include the reduction of fragmentation, avoidance of homogenization, consolidation of habitats in areas where large patches and/or large management units are needed or desired, and accommodating the needs of habitat specialists where the land is best suited to accomplishing that.
- There is, or has been, a tendency to treat the "stand" as an independent and somewhat static management entity. This may lead to management for a relatively narrow range of patch sizes, structural conditions, and even cover types, with the consequent loss of large habitat patches and diversity and increased habitat fragmentation due to the pattern, scale, type, and timing of management activities, greater potential for the isolation of populations of sensitive species, and ecological simplification over large areas. Individual habitat patches managed in this way tend to become more similar to one another. There is some potential for addressing such issues on public lands through the public lands property planning process, but there is also a need to offer a broader array of management incentives to private landowners than those currently offered under programs such as the Managed Forest Law (MFL) program to address some of these problematic shortcomings.
- Seek opportunities to make pine plantation management more compatible with maintaining the plants, animals, and natural communities native to Central Sand Plains Ecological Landscape. At some locations, such as on extremely dry sites where tree growth is poor, it may be biologically, silviculturally, and economically effective to phase out plantations, replacing them with either native dry forests or barrens vegetation. Elsewhere, the potential for eventually restoring the mixed pine-oak forests of the region as a management option for some sites currently occupied by plantations should be thoroughly examined. At some sites, existing plantations can play a role in reducing forest fragmentation, creating larger forest blocks, and increasing conifer cover. Future planning efforts could weigh alternative management scenarios for specific areas, making the decisions that would best satisfy ecological objectives at local and at broader scales. The practice of treating areas of native understory vegetation with herbicides—especially those composed of native prairie and savanna plants—should be reviewed and modified (if not terminated). Developing materials that will allow managers to recognize such vegetation is a key step.
- Promotion of the natural dynamic flux that (formerly) occurred between barrens and dry forests has been mentioned both here, in the "Extensive Forests" section and below in the "Oak and Pine Barrens" section. There is a strong tendency in traditional land management practices to perpetuate a "stand" as a given cover type once its initial cover type and management are defined. This can seriously limit management options due to inevitably changing ecological and socioeconomic conditions and may not be consistent with fulfilling our goals of "adaptive" management. It certainly doesn't "mimic nature" for these dynamic vegetation types.
- At least one, and preferably several, dry forests in the Central Sand Plains Ecological Landscape should be managed experimentally, primarily with prescribed fire and/or by prescribed fire combined with other methods.

Oak and Pine Barrens: Restoration, Management, and Protection

Pine Barrens and Oak Barrens are treated together here because they occupy similar sites, are both driven and maintained by periodic fire, and are susceptible to common threats. Floristically, the two types overlap to a great degree, but the differences can be important from a conservation perspective. For example, barrens with a tree layer composed mostly of pines will support very different bird species (e.g., Connecticut and Nashville Warblers, Hermit Thrush, Red Crossbill) that are either not present in or are very rare in barrens dominated by oaks. If the trees ("grubs") are mostly oaks, the bird community as well as certain invertebrates (e.g., buckmoths, *Hemileuca* spp.) will reflect that type. Brown Thrasher, Eastern Towhee, and Field Sparrow (*Spizella pusilla*) are more common in stands with woody deciduous species. When large scattered oaks are present, the resident birds may include Red-headed Woodpecker, Orchard Oriole, and Eastern Bluebird. Pine savannas in which large widely spaced red pines were the prevalent trees are unknown in this ecological landscape today.

Barrens communities of all types and structures are globally rare, geographically limited in distribution, and support

Vegetation on these ancient sand dunes is being managed with prescribed fire and mechanical brushing to restore oak barrens habitat at Necedah National Wildlife Refuge, Juneau County. Photo by Eric Epstein, Wisconsin DNR.

A dense black oak forest has been thinned and burned in an attempt to recreate oak barrens habitat. Necedah National Wildlife Refuge, Juneau County. Photo by Eric Epstein, Wisconsin DNR.

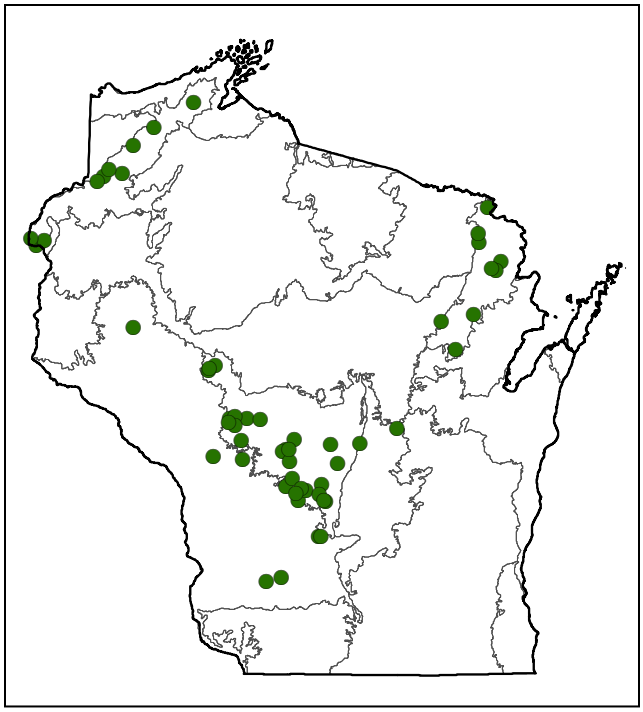


Figure 10.9. *Location of extant Pine Barrens in Wisconsin.*

many rare and declining plants and animals. In Wisconsin, barrens vegetation is restricted almost entirely to four ecological landscapes, including the Central Sand Plains Ecological Landscape (Figure 10.9).

Historically, this ecological landscape supported extensive barrens in the area now occupied by parts of the Black River State Forest, the Jackson County Forest, and the eastern part of the Eau Claire County Forest. Other barrens concentrations occurred on both sides of the Wisconsin River and along the western edge of the ecological landscape. Finley (1976), in his interpretation of the Public Land Survey notes of the mid-19th century, mapped extensive areas of barrens in what are now the counties of Adams, Eau Claire, Jackson, Juneau, Portage, and Wood.

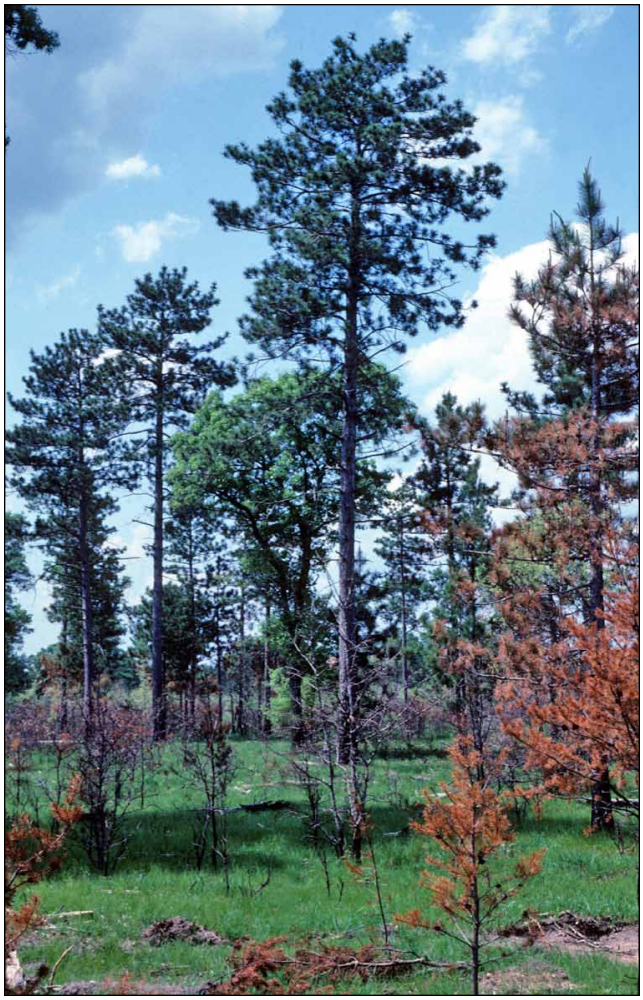
Barrens acreage declined precipitously because of conversion to agricultural uses following Euro-American settlement and through successional processes that followed the implementation of widespread fire suppression policies in the 1920s and 1930s and ultimately resulted in dense forests of pine or oak. Many remnant barrens now occur along roadsides and within other rights-of-way (for example, along railway and utility corridors) and on some sites with coarse-textured soils of low nutrient status that are relatively unfavorable for the growth of trees. In recent years, wildfires have occurred in several areas overgrown with woody vegetation that historically supported barrens. The fires reduced woody cover and in a few instances revealed a wealth of native prairie species that had been suppressed but not yet eliminated by heavy shading. The Bauer-Brockway Barrens State Natural Area, on Jackson County forestland in eastern Jackson County, was "discovered" after it had burned in a fire started along railroad tracks to the west in the mid-1970s. A similar situation occurred more recently on the Eau Claire County Forest (the "Canoe Landing Fire") where a wildfire revealed a flora rich in native prairie species and rare invertebrates (B. Ludwig, Wisconsin DNR, personal communication). Other "accidental" fires have been less revealing because the barrens vegetation had declined to the point where it had been eliminated prior to the fire (Leach and Givnish 1996, 1999); the site had been badly damaged in some way (e.g., by plowing, heavy grazing, or dense infestations of invasive plants) and no longer supported a barrens flora of native plants, or the site had no connection to historical barrens and had most likely historically supported forest or some other vegetation type.

Barrens remnants and restoration opportunities are concentrated in those parts of the state that have drought-prone sandy soils of low nutrient status and level or gently rolling topography that will allow fires to run for long distances

unimpeded and that were historically subject to frequent wildfires. Many remnants are now in poor condition because of the prolonged periods of fire suppression that led to the proliferation of woody vegetation that weakened or eliminated many shade-intolerant species or species that required large open areas to meet their basic habitat needs. Large areas of former barrens have been planted to red pine monocultures, and some of these sites were sprayed with herbicides to control competing vegetation (which in some cases was composed mostly of native forbs, grasses, and shrubs), resulting in the diminished representation by or loss of native prairie/barrens understory plants.

Key barrens species of conservation focus here include the U.S. Endangered Karner blue butterfly, the Wisconsin Endangered phlox moth and sand violet, the Wisconsin Threatened Blanding's turtle and dwarf milkweed, and the rapidly declining Wisconsin Special Concern species Sharp-tailed Grouse. Many other animals (e.g., those identified in the Wisconsin Wildlife Action Plan as Species of Greatest Conservation Need [Wisconsin DNR 2005b]), including mammals, birds, herptiles, and invertebrates, are either dependent on or are strongly associated with, barrens habitats.

The globally imperiled Kirtland's Warbler has recently been found nesting in the Central Sand Plains (Trick and Grveles 2010), and there may be good potential for developing a viable breeding area for this species in central Wisconsin; previously, the Kirtland's Warbler was known to nest only in a few counties in Michigan's Lower Peninsula. This discovery underscores the need to identify critical management areas for this species throughout this ecological landscape in the near future to promote flexibility and enable planners and managers to make the most effective decisions regarding Kirtland's Warbler conservation.



Pine barrens restoration project. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Management Opportunities, Needs, and Actions

- Protecting barrens remnants is a conservation priority in the Central Sand Plains Ecological Landscape due to historical factors and extant remnants. Opportunities should be sought to maintain remnants, connect them periodically, and enlarge open areas where feasible and appropriate. Major management goals include maintaining the vegetation in an open or semi-open condition by using tools such as prescribed fire and mechanical brush removal, avoiding patch and population isolation, identifying sites that are appropriate for barrens restoration, controlling invasive species, and identifying opportunities to create patches that are large enough to support the broadest array of barrens-associated wildlife possible.
- The Central Sand Plains is one of Wisconsin's top ecological landscapes for promoting large-scale (up to 10,000 acres) barrens management. Restoration potential remains relatively high, despite widespread conversion of barrens into sites emphasizing forest production. Intrinsic site characteristics and susceptibility to periodic drought have made some locations unfavorable for other uses, including agriculture and commercial forestry. If adequate incentives can be developed, there should be legitimate opportunities in some areas to restore barrens at the scale of 1,000 acres to roughly 10,000 acres. Aggregating harvests, configuring management units to maximize large contiguous open patches rather than edge, and periodically connecting isolated barrens patches have been mentioned as means by which the effective area could be increased. There are also opportunities to prevent further loss of sensitive native species by identifying small scattered openings that still support a complement of native barrens plants and animals within areas that are otherwise forested. These remnants are often small and could be easily protected using minor modifications to existing forest management prescriptions, even on lands managed primarily for wood products. Managers will require administrative support, materials that enable them to identify such areas, and an effective planning process that allows patches of important habitat to be incorporated into stand-level management plans.

- Public lands generally offer the best opportunities to manage for barrens at the larger scales. Tools available to public lands managers include prescribed fire, mechanical brush cutters, herbicides, and the institutional memories of employees as well as the trained staff and equipment needed to do this kind of management safely and effectively. There are now good examples of this type of management in the Central Sand Plains on federal, state, county, and several private lands. Eau Claire County has designated two barrens sites on their county forest as State Natural Areas—Coon Fork Barrens and South Fork Barrens, both of which are actively managed to maintain the barrens community using timber harvests, mowing, and mechanical reduction of woody fuels. Bauer-Brockway Barrens, a State Natural Area on the Jackson County Forest, is an excellent example of a medium-scale county and state partnership dedicated to barrens restoration and management. Other barrens sites managed by federal, state, and county governments are scattered across the western part of the ecological landscape.
- One nongovernmental organization (NGO), The Nature Conservancy, has a significant project at Quincy Bluff in southern Adams County to protect and restore a large block of pine and oak barrens, dry forest, and peatlands. The Wisconsin DNR is a major partner in this endeavor.
- Acknowledging the dynamic and highly variable nature of barrens ecosystems, seek opportunities to represent the full range of patch sizes and structural features characterized by historical barrens in this ecological landscape (Mossman et al. 1991). The range of variability characteristic of barrens communities includes stands dominated by scattered small trees (either oaks, pines, or mixtures of oaks and pines), stands with scattered large trees ("savannas"), open stands with herbs and low shrubs dominant, and less abrupt transitions between the managed barrens (which have often been kept in an essentially treeless condition) and adjacent forest. Today, in many areas the surrounding forests may form "walls" around managed barrens vegetation, creating extensive "high contrast" edge. Maintaining or restoring structural and compositional variability is critical to meet the needs of area-sensitive species and habitat specialists dependent on small-scale microsites or disturbances (e.g., sand blows, badger dens, pocket gopher mounds, downed wood, populations of a particular host plant). In terms of composition, it is desirable to maintain representation of not only the diverse prairie grasses and forbs, but patches of "heath" (blueberries [*Vaccinium angustifolium*], bearberry [*Arctostaphylos uva-ursi*], sweetfern [*Comptonia peregrine*]) and native shrubs such as prairie willow (*Salix humilis*), serviceberry (*Amelanchier* spp.), and hazelnut (*Corylus* spp.). Providing large stands of open barrens is the most urgent need at this time due to the great degree to which most lands in the historical barrens areas have become overgrown with woody vegetation. However, at least some representation of other barrens structural variants is also necessary, i.e., stands that are intermediate between the treeless barrens and densely stocked stands of scrubby timber. For jack pine and the "scrub" oaks (which may live to well over a century), it is also ecologically important to have representation of patches that are beyond rotation age because the trees in such stands will have structural characteristics not represented elsewhere.

This pine and oak barrens restoration site is on the Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

- Seek opportunities to better integrate the restoration and management of barrens with dry forests. Some of the best opportunities to do this may occur on the Boone Sands, considered by at least some soil scientists to be the least fertile soils in Wisconsin (Hole 1976). These soils occur in the western part of the Central Sand Plains. Even plantations might be incorporated into a landscape scale barrens management plan, with greater emphasis on adjusting stand shapes, boundaries, harvest schedules, and post-harvest treatments and, in certain locations, aggregating rather than dispersing final harvests. Forest management could be conceptually broadened to better ensure that sensitive species present in the managed forestlands are not lost. In some areas, forest diseases, e.g., oak wilt, have created or maintained gaps in the forest canopy that have allowed light-demanding flora and some associated animals to persist. Maintaining openings caused by disease or other forest pests could have significant benefits under limited circumstances.
- Additional field inventory is needed to identify remnant barrens, populations of rare barrens species, and disturbed, relatively unproductive areas now used for agricultural or commercial forestry purposes, with legitimate restoration potential. Historical barrens east of the Wisconsin River are mostly in private ownership, including large acreages of industrial forest. The conservation potential of these lands has not been fully evaluated, but conversion to pine plantations has been common in that

part of the ecological landscape. Basic inventory work to identify and assess barrens remnants, rare species populations, and sites with the best restoration potential is a priority in the near-term and would best be conducted over the entire ecological landscape.

- Well-defined management objectives and prescriptions, along with good communication, adaptive resource management, and effective means to resolve conflicting management objectives are needed to protect and manage the globally rare Pine and Oak Barrens communities. Conflicting management goals for barrens have been a common issue, even within public agencies, and may continue to be problematic for the near-term. It is necessary for planners and managers to understand the importance and imperiled nature of this community and the large number of associated rare or declining plants and animals that are dependent upon it.
- Invasive plants are now serious problems in barrens habitats just outside of the Central Sand Plains Ecological Landscape (e.g., at Fort McCoy, just to the southwest, in the Western Coulees and Ridges Ecological Landscape), but within this ecological landscape, species such as leafy spurge, cypress spurge, and spotted knapweed appear controllable at many locations. Eradicating such populations should be a management priority. Wisconsin Department of Transportation and county highway departments need to be major partners in control efforts because roads and maintenance equipment are among the means by which these invasive plants spread.

Rivers and Streams, Floodplains, Riverine Lakes, Riparian Corridors

The largest rivers flowing through the Central Sand Plains Ecological Landscape are the Wisconsin and Black. Both are classified as warmwater rivers, as are the other large streams here, such as the Yellow, Lemonweir, Plover, East Fork of the Black, and the North Fork and South Fork of the Chippewa River. The East Fork of the Black River is a warmwater stream noted for its good water quality, intact aquatic and adjoining wetland habitats, and diverse assemblages of fish and invertebrates. The lower Lemonweir River supports a population of the globally rare salamander mussel.

Notable coldwater streams include the Little Lemonweir River (Monroe and Juneau counties); White, Big Roche a Cri, Fordham, and Fairbanks creeks (Adams County), and the lower reach of Tenmile Creek (Wood County). Exceptional Resource Waters include all or portions of Campbell, Corning, Fairbanks, Gulch, and Plainville Creeks (Adams County). Upper Perry Creek (Jackson County) features coldwater seeps and moss-covered sandstone bedrock that support rare insects. Crawford, Halls, Levis, Morrison, and White creeks (Jackson County) are examples of cool-to-coldwater streams with good water quality and healthy assemblages of aquatic life.

Sand-bottomed, spring-fed coldwater stream with clear, amber-colored waterstained by peat. Wetlands pictured here include Alder Thicket, White Pine-Red Maple Swamp. Robinson Creek, Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

This stretch of the Yellow River has an extremely low gradient and features a broad, mostly forested, floodplain. Juneau County. Photo by Eric Epstein, Wisconsin DNR.

The hydrologic manipulations that result from managing water levels for various purposes can compromise the biological integrity of impoundments and the streams flowing into and from them. Planning is needed to ensure that impoundment water levels provide secure habitat for nesting birds and to avoid inadvertent damage to fish, mussel, amphibian, and reptile populations during droughts or drawdowns. While impoundments create open water habitat and deep marshes that benefit some species, they may also inundate existing wetlands, potentially diminishing shallow marsh, sedge meadow, bog, and lowland forest habitats to the detriment of the species dependent on them. Periodic region-wide assessments of wetland habitats are needed to provide information that will help ensure that meadow, marsh, and bog communities are maintained in sufficient quantities and in enough locations to conserve all of our native wetland communities and their associated species.

Several rivers passing through and draining this ecological landscape have developed extensive and complex floodplains. The most abundant natural community associated

Extensive floodplain forest occurs at the confluence of the Lemonweir and Wisconsin Rivers. Juneau County. Photo by Eric Epstein, Wisconsin DNR.

with floodplains of the large rivers here is Floodplain Forest, a type dominated by deciduous trees adapted to periodic inundation. Slight changes in elevation within the floodplain create a diversity of soil textures, soil nutrients, and soil moisture conditions, and these partially account for the complex vegetation mosaic present in floodplain systems. Rare species associated with floodplain forests include Red-shouldered Hawk, Cerulean Warbler, Prothonotary Warbler, and beak grass. Great Egret and Great Blue Heron (*Ardea herodias*) sometimes establish breeding colonies within this forest type.

The lowest areas of floodplain are constantly saturated and periodically inundated and may support stands of shrub swamp (usually of the "Shrub-carr" type, with dogwoods and willows dominant), sedge meadow, or marsh. Where the floodplains have not been affected by dams, wetlands of these types tend to be small and relatively uncommon and are most stable only in protected backwaters or abandoned oxbows. These types do occur within impoundments, where water level manipulations can alter their structure and composition over short periods of time. An exceptional sedge meadow on the Eau Claire County Forest has been designated as a State Natural Area (Pea Creek Sedge Meadow State Natural Area).

Higher portions of the floodplain, which in at least some cases are older river terraces, are generally forested. The highest terraces adjoining the floodplain contain many of the documented stands of mesic sugar maple-basswood forest (Southern Mesic Forest) within the Central Sand Plains Ecological Landscape. Some of these mesic hardwood stands support rich assemblages of herbs that include species that are regionally rare or of very limited distribution here. Drier areas with sandy soils can support dry-mesic (or even dry) forests dominated by oaks, sometimes with a component of eastern white pine. These higher, older terraces sometimes exhibit undulating ridge-and-swale topography. In such cases, seepages and springs may be common features at the bottom of the sandy or rocky bluffs bordering the floodplain. Such areas may harbor exceptionally high plant and animal

The ecological significance of floristically rich maple-basswood forests, such as this stand on a terrace along the Black River, is sometimes overlooked. This forest community is rare in the Central Sand Plains and supports three Wisconsin Threatened species. Photo by Eric Epstein, Wisconsin DNR.

diversity, support rare species, provide clean, cold water to river systems, and warrant strong protection.

Along the western edge of the ecological landscape, some stretches of the Black River are bordered by steep bluffs forested with oaks, pines, and maples. Site conditions are generally dry-mesic, and the dominant pines and oaks have the potential to attain large size. Outcroppings of Cambrian sandstone and spring seeps are present. Areas in public ownership are relatively undisturbed, but logging and residential development are occurring on some of the privately owned areas. Above the bluff tops, conditions are usually dryer, and many of the forests there are intensively managed for short-lived species such as jack pine or have been recently converted to red pine plantations. Scattered patches of barrens vegetation persist on some of the bluff top sites, but these are increasingly restricted to roadsides or other rights-of-way where they are highly threatened by combinations of right-of-way maintenance activities, isolation, and the heavy shade produced by encroaching woody vegetation.

The floodplains of other major rivers within the Cenral Sand Plains Ecological Landscape (including the Lemonweir, Yellow, Eau Claire, and East Fork of the Black) tend to transition to dry, sandy uplands without the complex topography or vegetation mosaic that occurs along some reaches of the Black River. The floodplain of the Wisconsin, the largest river crossing the Central Sand Plains Ecological Landscape, has been strongly modified by the large dams that created the huge Castle Mound, Petenwell, Biron, and Wisconsin River flowages. In the areas affected by the impoundments, much of the floodplain vegetation has been permanently inundated and the adjoining forests destroyed. Several important stretches remain partially intact—for example, above Wisconsin Dells, from approximately the mouth of the Lemonweir River north to Castle Rock Flowage and from the north end of the Petenwell Dam to Biron (just north of the city of Wisconsin Rapids).

The large floodplains of the Central Sand Plains Ecological Landscape support extensive forests of high value to specialized plants and animals, and these forests could also serve as connecting corridors with landscapes to the north, south, and west. Management challenges and, in some cases, environmental threats are posed by dams, sediment and pollutant-laden runoff, the continued spread of invasive species, and activities that fragment, isolate, or simplify the natural communities or habitats present. The development of shorelines for residential use continues. Regeneration of some of the dominant trees of the Floodplain Forest remains problematic, even under the best of circumstances. Species of low commercial value (e.g., river birch, silver maple, eastern cottonwood [*Populus deltoides*], hackberry [*Celtis occidentalis*]) may be of especially high concern because incentives to maintain them are lacking. Impacts of the emerald ash borer to populations of ash trees could be devastating, perhaps even more so than the ravages created in the recent past by Dutch elm disease (caused by the fungus *Ophiostoma ulmi*).

Several small streams originate in the large peatlands now occupying the central portion of the Central Sand Plains. Where these streams remain free-flowing and the channels have not been dredged or straightened, the diversity of aquatic

Rapids created by exposures of Precambrian bedrock in the Black River. Jackson County. Photo by Emmet Judziewicz.

Morrison Creek and its associated cliffs and forests provide important habitat for diverse assemblages of plants and animals. Black River State Forest, Jackson County. Photo by Richard Bautz.

Large, sedge-dominated open peatland (Central Poor Fen), headwaters stream. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

taxa, especially invertebrates, can be significant. In their upper reaches, some of these streams exhibit extremely low gradients as they flow through nearly level landscapes featuring large peatlands, extensive dry forests, and remnant barrens. Closer to the Black and Wisconsin rivers, some tributaries begin cutting through the underlying sandstones, forming gorges where stream gradients increase dramatically (at some locations these are referred to as canyons, gulches, and glens). The streamside vegetation in these areas may consist of linear but extensive stands of large eastern white pine and its associates, which may grow both on and above sandstone cliffs. Good examples occur along tributaries of the Black River in Jackson County, such as Morrison, Perry, Dickey, Halls, and Valentine creeks. Very small streams now occupy the spectacular gorges created during the catastrophic drainage of Glacial Lake Wisconsin, at Witches Gulch, Coldwater Canyon, and at several other locations near the southern edge of the ecological landscape in and around the city of Wisconsin Dells.

Management Opportunities, Needs, and Actions

- Maintain the extensive Floodplain Forests that provide much of the vegetation matrix for undammed portions of the large river systems. These create the vegetation matrix within which less abundant communities such as marsh, sedge meadow, and shrub swamp occur. Where the floodplains are broad and complex or where the rivers are confined by steep bluffs, there may be opportunities to effectively protect and manage complexes of relatively uncommon or poorly protected forest communities (examples may include Forested Seep, Moist Cliff, Southern Mesic Forest, and Northern Dry-mesic Forest) within a matrix of larger patches of communities such as Floodplain Forest. At some sites, there will be opportunities to integrate plans for the management and protection of floodplain habitats with those for adjoining uplands.

- Managing larger, interconnected units may greatly enhance the ability of these more limited community types to support sensitive forest interior species. For example, the only breeding season records in the Central Sand Plains Ecological Landscape for Acadian Flycatcher and Kentucky Warbler, both Wisconsin Threatened birds, came from mesic maple-basswood forest on the Black River State Forest within a much more extensive area of forested floodplain and mixed dry-mesic pine-oak forest. The adjoining dry-mesic pine-oak forest also supports sensitive forest interior species such as Red-shouldered Hawk and Black-throated Green Warbler (*Setophaga virens*). Bald Eagle and Common Raven (*Corvus corax*) have been found nesting in older, undisturbed stands of pine and oak adjacent to the river floodplains.

- Eastern hemlock stands are extremely rare in this ecological landscape, but they do occur at a few locations where they are associated with sandstone cliffs along the Wisconsin and Black rivers. Mesic hemlock-hardwood forest occurs on several islands within the Wisconsin River floodplain in the northeastern part of the ecological landscape. These scattered occurrences of regionally uncommon forest communities will have greater conservation value if managed as integral components of larger forested ecosystems.

- Advocate for opportunities to restore natural habitats along the Wisconsin and Black rivers. Although efforts to control point source pollutant discharges over the past 20 years have resulted in better water quality, continued study and monitoring of the Wisconsin River and its tributaries to assess the need for additional water quality improvements are warranted. Continue to protect sensitive shoreland habitats through easement, acquisition, or other means.

- Continue to seek opportunities to remove dams to improve habitat for aquatic organisms such as the lake sturgeon in the Yellow River and other streams that historically supported sensitive species.

- Monitor success of groundwater withdrawal agreements to protect flows in the Plover River and other streams potentially impacted by groundwater withdrawals. Continue to monitor and assess consumptive uses and their impacts on groundwater, surface water, and aquatic life. Where possible, regulate withdrawals or work with local communities and other partners to reduce or eliminate negative impacts. Encourage water conservation measures to minimize these impacts.

- Encourage implementation of best management practices (BMPs) for logging and other activities near waterways and encourage stream buffering for land that is in agricultural use. "Habitat" BMPs remain a continuing need for riparian areas and wetlands.

- Identifying the sources of excess nutrients that are responsible for the poor water quality in impoundments associated with the Wisconsin River and its tributaries, and devising and implementing a plan to remedy that situation, would have enormous ecological, recreational, and socioeconomic benefits. In 2009 the Wisconsin state legislature appropriated $150,000 per year for five years to conduct a monitoring and modeling study in the Wisconsin River basin from Castle Rock Dam upstream to the city of Merrill. This is a great start, but additional, and continuing, support is needed.

- Protect water quality and habitat of rivers and streams that currently exhibit good to excellent water quality and high habitat values. Protect free-flowing stream segments against dam placement and other actions that could fragment habitat and alter hydrology. Continue to provide input to local development plans and support measures that minimize flow, nutrient, and temperature impacts to coldwater streams. Work with county zoning

officials, lake management districts, local communities, and other organizations to develop higher protection standards for resources that fall under the classification of Exceptional Resource Waters (ERW) or Outstanding Resource Waters (ORW). Evaluate impacts to water quality from nonmetallic mining through permit compliance monitoring. Develop more holistic riparian management plans on state-owned and easement properties, not focused solely on game fish. Maintain oxbows, meanders, and scattered patches of natural vegetation within and adjacent to floodplains.

- Encourage landowners in priority watersheds to apply for nonpoint source grants to install pollution abatement equipment. Assess the impacts of existing dams on streams and ditches. Where negative impacts are occurring, encourage dam removal and oppose the construction of new dams. Continue to address the restoration needs of impaired waters on the 303(d) list, especially through the total maximum daily load (TMDL) analysis.
- Track the need for repairs on dams forming impoundments (such as Easton Lake) on good quality streams and add fish passage structures as appropriate when dam owners are developing plans to make repairs. Encourage lake districts and lake associations to apply for Lake Planning Protection Grants to monitor water quality and perform water quality enhancement projects.
- Work with lake management districts and the Wisconsin DNR Invasives Team to develop further research and strategies to minimize invasive species that are present in the ecological landscape's aquatic and wetland habitats (e.g., zebra mussel [*Dreissena polymorpha*], Eurasian water-milfoil, rusty crayfish, purple loosestrife, curlyleaf pondweed, reed canary grass, common carp).
- Cooperate with large dam owners that manage and maintain dams, such as Wisconsin Valley Improvement Corporation, Stora-Enso, and hydropower companies, to maintain the ecology and diversity of the rivers they manage.
- Identify streams from which the removal of dams is feasible and would have ecological benefits.
- Connect tributaries and their associated vegetation to the large rivers where possible. Opportunities to connect some of the smaller streams and their associated vegetation to the floodplains of the large river systems are important because they can represent habitats that are less abundant in the larger floodplain systems, facilitate dispersal of some desirable animals and plants, and reduce habitat isolation. Significant wetland vegetation may occur along the floodplains of some of the small streams, especially those that have not been dammed and impounded, channelized, or subjected to heavy shoreline development. Important natural communities associated with small streams include Alder Thicket, Northern and Southern Sedge Meadow, Central Poor Fen, Northern Dry-mesic Forest, Pine Barrens, and Oak Barrens.
- Consider ecological gradients and connections within and across floodplain ecosystems. Floodplain planners and managers need to consider the entire gradient of natural communities and aquatic features from the main channel across the floodplain to the adjoining uplands as well as the connectivity a forested floodplain can provide both within and across ecological landscapes. Avoid activities (e.g., constructing a road at the wetland-upland interface) that fragment, isolate, or simplify floodplain systems and their associated natural communities and those that impair site hydrology.
- Novel conservation opportunities may be identified. For example, depleted sand and gravel quarries bordering the Black River may one day, following their eventual abandonment, offer opportunities for innovative habitat restoration and management.

Peatlands: Forested and Nonforested

Wetlands occupying poorly drained areas of sandy glacial lakebed or outwash sands are abundant in the Central Sand Plains Ecological Landscape. The combination of subdued topographic relief, coarse textured soils, and a high water table creates stark and sharply marked contrasts between the xeric uplands and adjoining wetlands, resulting in a complex vegetation mosaic based on slight elevational differences and past disturbance events. The presence of relatively impervious sediments (silts and clays) deposited on the bottom of Glacial Lake Wisconsin is thought to be responsible for the existence of the vast wetlands that now cover significant portions of this ecological landscape. The core of this peatland-dominated area occupies parts of Jackson, Juneau, Monroe, and Wood counties and has been referred to as the "Great Swamp of Central Wisconsin" (see Figure 10.2 in the "Wetlands" section above).

Many peatlands in this ecological landscape have been subjected to hydrological alterations since Euro-American settlement. Initially the intent was to drain the land and improve its potential for agriculture. Many of these attempts were failures, especially west of the Wisconsin and Yellow rivers. Subsequent modifications, following abandonment of the land by settlers or their resettlement to areas more conducive to farming, were done under the direction of public agencies, often as they attempted to restore wetlands by plugging ditches and constructing extensive dike systems.

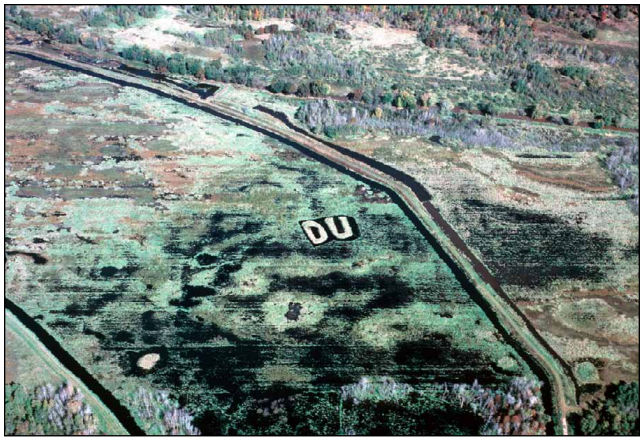
Most of these wetlands can be grouped as "acid peatland" communities: bogs, poor fens, muskegs, and conifer swamps, all of them characterized by a more or less continuous carpet of sphagnum mosses upon which a limited but specialized group of sedges, ***ericaceous shrubs***, insectivorous plants, and coniferous trees grow. Physiognomically and floristically, the peatlands of the Central Sand Plains Ecological Landscape

resemble the boggy wetlands of northern Wisconsin, but species do occur in the central part of the state that are not found or are very scarce in regions farther north. See the "Flora" section of this chapter and also see Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book for additional information on central Wisconsin peatlands.

The peatland forests are composed almost entirely of conifers, with tamarack and black spruce the dominant species. Jack pine is sometimes important and is a dominant tree in some stands. Other tree species are incidental, although eastern white pine can be important on slight rises or on the peatland margins. The acid conifer swamps of the Central Sand Plains can be quite extensive (though in many areas they have been reduced by drainage or other forms of hydrologic disruption), and these larger, more functionally intact stands support a boreal fauna that may include mammals, birds, butterflies, and moths at or close to their southern range limits.

Wet-mesic forests are represented by an ecologically important and geographically limited community that sometimes occupies transitional zones at the wetland-upland interface. This is the White Pine-Red Maple Swamp (more fully discussed under "Miscellaneous Natural Features"), a community that occurs on mucks and shallow peats over partially saturated sand. A high water table favors the growth of an understory composed mostly of and dominated by wetland species. This is a structurally complex forest community that supports a distinctive assemblage of plants and animals, including some that are rare. Groundwater seepage is a characteristic and important attribute of this forest type, and spring runs or headwaters streams originate from some stands. Though not classified as a peatland community, this type often adjoins peatlands, may support a ground cover of sphagnum mosses, and should be managed with contextual considerations, hydrological sensitivity, associated rare species, and scale in mind.

Collectively, the lowland coniferous forests of the Central Sand Plains Ecological Landscape constitute a tremendous repository of significant birdlife, which includes several rare species and many northern species breeding at or near their extreme southern range limits. Among these species are Northern Goshawk, Sharp-shinned Hawk (*Accipiter striatus*), Common Raven, Northern Saw-whet Owl (*Aegolius acadicus*), Red-breasted Nuthatch (*Sitta canadensis*), Yellow-bellied Flycatcher (*Empidonax flaviventris*), Winter Wren (*Troglodytes hiemalis*), Golden-crowned Kinglet (*Regulus satrapa*), Hermit Thrush, Veery, Blue-headed Vireo, and many wood warblers, including the Blackburnian (*Setophaga fusca*), Black-throated Green, Canada (*Cardellina canadensis* but listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List*)*, Connecticut, Yellow-rumped (*Setophaga coronata*) as well as Northern Parula (*Setophaga americana*) and Northern Waterthrush (*Parkesia noveboracensis*). Red Crossbill and Merlin (*Falco columbarius*) have been found in summer at several locations here. White-throated Sparrow (*Zonotrichia albicollis*) is locally common in cutovers or shrubby margins, and the Lincoln's Sparrow (*Melospiza lincolnii*) has been found recently during its breeding season in "Muskeg" habitat (which also occasionally supports Golden-winged Warbler, although this is not its most common breeding habitat).



These formerly drained and cropped wetlands in Juneau County have been partially restored. Note "signage" by one of the partners. Photo by Eric Epstein, Wisconsin DNR.

Starlight Peatlands is a large complex of forested, shrub-dominated, and open wetlands on the Black River State Forest. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Tall shrub communities develop in mucks and peats and commonly occur along streams or on wetland-upland margins. Alder Thicket is the most common tall shrub community here, though other shrubs such as bog birch (*Betula pumila*), winterberry holly (*Ilex verticillata*), huckleberry (*Gaylussacia baccata*), and chokeberry (*Aronia melanocarpa*) may be locally common or even dominant. Mucks may replace peats as the most important soil groups in areas dominated by these species. Animals associated with such habitats in the Central Sand Plains include Golden-winged Warbler, Veery, American Woodcock, Alder Flycatcher, snowshoe hare, and wood turtle.

The open peatlands are dominated by sedges and other graminoids, which often grow upon a continuous carpet of "peat" mosses. The shrub layer consists of bog ericads but usually includes only a subset of the ericads that are common, widespread, and characteristic of acid peatlands farther north. Whether this is due to geographic location and climate (the Central Sand Plains is at or near the southern range limits for some of the common bog shrubs); past hydrologic disruption; the repeated commercial harvest of sphagnum moss (a practice that is rare or unknown in other parts of Wisconsin); past fires; or some combination of these factors is unclear. The open peatlands provide important habitat for many rare plants and animals, including birds, herptiles, and invertebrates. Pools, mammal trails, and disturbed edges can support plants belonging to the "Atlantic Coastal Plain disjunct" group described in the "Flora" section of this chapter and also constitute important microhabitats used by other sensitive species.

Sedge meadows receive water and nutrients from surrounding lands via both overland flow and groundwater seepage but can and do occur in some of the same basins that contain the more acid peatland communities. Sedge meadows also occur on the borders of streams and rivers and on the margins of some flowages. Sedge meadows lack the near-continuous carpet of sphagnum mosses demonstrated by black spruce and tamarack swamps, Muskegs, Open Bogs, and Poor Fens and therefore do not exhibit the low pH, low oxygen levels, and high acidity that characterize those communities.

The historical role played by fire in maintaining sedge meadows and other wetland communities in the fire-prone Central Sand Plains Ecological Landscape needs further study. The natural hydrological regimes of many wetlands in this ecological landscape have been severely disrupted. Ditching, diking, dredging, channelization, and other wetland modifications are widespread, and their ultimate impacts on hydrologic function and vegetation are not well understood.

Extensive wetlands of sedge meadow and poor fen occur at Dike 17 Wildlife Area, which is within the boundary of the Black River State Forest. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Severe fires were said to have burned deeply into peat deposits in the drought years of the 1930s. The water table in Juneau County dropped by as much as 12 feet in some of the areas that were drained in the early 20th century (Goc 1990). The issue needs to be studied in detail because the conservation, restoration, and management implications are huge.

Management Opportunities, Needs, and Actions

- Coordinate management of forested peatlands with adjoining uplands, especially if the adjoining upland forests are mostly coniferous. This will increase the area of habitat available for species dependent on or strongly associated with coniferous forests and reduce potential for isolating and exposing such forests, composed mostly of shallow-rooted species, to excessive wind damage.
- Consider open vegetation types together to better accommodate the habitat needs of at least some area-sensitive open country species. Where barrens restoration is being attempted, adjoining open bogs, meadows, and fens can add to the large open landscapes favored or needed by area-sensitive species such as Sharp-tailed Grouse or Northern Harrier. Similar considerations may apply where surrogate grasslands adjoin sedge meadows or open peatlands. Forest BMPs will not always be ecologically appropriate in such situations, and modifications should be considered to fit the circumstances and needs of the local environment.
- Enlarging the mosaic of treeless habitats is possible at some locations and may also include uplands supporting surrogate grasslands. It should be cautioned, however, that clearing areas of coniferous forest, especially conifer swamps, in order to develop larger treeless openings is not necessarily a good trade-off. Such actions can result in habitat loss for sensitive forest dwelling species and will also necessitate active management to periodically reduce woody cover. A landscape-level approach to planning is useful and probably necessary to aid in the determination of the ecological costs and benefits associated with creating large openings versus maintaining other habitats such as contiguous forest or scattered patches of swamp conifers. Among the important considerations needed for this approach at any given site are the context of the site, knowledge of the local and regional status of the resident flora and fauna, the present and future necessity of conducting active management, and the site's ecological capabilities.
- Establishing one to several peatland Bird Conservation Areas merits consideration here, as the land and habitat base exist, and most of the associated birds of conservation concern are here now.
- Clarify the impacts of the hydrological disruptions that have occurred throughout this ecological landscape. Long-term impacts of these hydrological modifications are unknown, and disturbed and undisturbed sites should

be closely monitored. Past, present, and future groundwater withdrawals are among the many complicating factors, as is the history of fire suppression.

- Assess wetland restoration needs by type. Wetland restoration has often been limited to efforts that favor marshy vegetation (primarily because of its value to certain waterfowl), rather than bogs, fens, sedge meadows, or conifer swamps. An assessment of the degree of conversion that has occurred in this ecological landscape, at least on the public lands, is needed. Such conversions should not proceed without periodic assessment, including an evaluation of how successful these efforts have been. Many parts of the Central Sand Plains Ecological Landscape have highly acidic ground and surface waters and may not be well suited to the kinds of wetlands restoration and management that have occurred elsewhere in the state, i.e., in areas that historically supported highly productive, fertile marshes, and large numbers of waterfowl.
- Invasive plants are present, and certain land uses may be facilitating their spread. Invasive species are not a widespread threat at this time, but common reed, reed canary grass, hybrid cat-tail (*Typha* x *glauca*), and purple loosestrife are established locally, and these populations should be better documented, mapped, and monitored.
- A study of the impacts of commercial moss harvest on the flora and fauna of peatlands in central Wisconsin is needed. The commercial harvest of sphagnum moss needs additional study so that its impacts are better understood. Areas on state-owned or managed public lands that are known to support rare plants or animals should not be open to moss harvest until such a study has been completed. The species of moss involved, disruption of nesting birds, destruction of populations of rare plants (all living plant material is removed in the areas from which moss is being removed), and the degree and rate of peatland community recovery are among the issues that need to be addressed by public land managers. Several rare species use mossed habitats, and these associations also need to be clarified to help understand the management considerations.
- When and where appropriate, mossing may have some potential as a management tool for the Henslow's Sparrow (and perhaps other species), which can occur in high densities in mossed habitats, at least for short periods of time. However, little is known about other impacts of this practice, and there are needs for both more research on mossing and the establishment of unmossed core peatland habitats throughout the Central Sand Plains.
- The Wisconsin DNR Statewide Peatlands Project (Anderson et al. 2008) grew out of the need to determine the rarity of the Wisconsin Natural Heritage Working List species associated with peatlands across the state and should provide useful information for managers and conservation planners. Additional knowledge, however, is still needed on the identification, distribution, relative abundance, and ecology of the mosses occurring in Wisconsin peatlands. Relatively detailed information is available for the acid peatlands of Michigan (Crum 1988), Minnesota (Glaser 1987), and Ontario (Harris et al. 1996), but that is not a substitute for locally obtained information that is needed to best ensure the successful conservation and management of Wisconsin's peatlands.
- Commercial cranberry operations may have the potential to maintain some peatland habitats as well as ensuring that the landscape remains wet rather than drained. Impoundments, however, have resulted in extensive loss of conifer swamps and warmer surface water.
- Incentives are needed to encourage private and some public landowners to protect rather than exploit or convert peatland communities such as conifer swamps, Muskegs, Poor Fens, Open Bogs, and Northern Sedge Meadows.

Surrogate Grasslands

Large areas of nonnative "surrogate" grassland on the level terrain east of the Wisconsin River and southwest of the city of Stevens Point have been managed for decades by the Wisconsin DNR to provide breeding habitat for a "remnant" population of the Greater Prairie-Chicken. Historically, this area was vegetated with a mosaic of large peatlands, barrens, and xeric forests, but following settlement by Euro-Americans, the wetlands were drained and the forests cleared for agricultural purposes. While this area now supports relatively little native vegetation, the extensive grasslands here constitute one of Wisconsin's most important management opportunities for grassland birds, including many species that are experiencing local, regional or rangewide declines.

Current land cover includes blocks of permanent grass, composed mostly of nonnative "cool season" species such as Kentucky and Canada bluegrass (*Poa pratensis* and *P.*

The vast Buena Vista Grasslands provide critical habitat for declining grassland birds, including the Greater Prairie-Chicken (Wisconsin Threatened). Portage County. Photo by Eric Epstein, Wisconsin DNR.

compressa), smooth brome (*Bromus inermis*), orchard grass (*Dactylis glomerata*), timothy (*Phleum pratense*), and quack grass (*Elytrigia repens*), intermixed with areas of pasture and cropland. A few sites support a limited complement of native prairie plants, but these areas are minor in extent.

In recent decades, the implementation of more intensive agricultural practices (e.g., the development and spread of center pivot irrigation) has diminished the amount of suitable habitat available for many native grassland species of conservation concern. Apart from those lands managed specifically for conservation purposes, land that is not pastured or sharecropped to provide winter food for Greater Prairie-Chickens is tilled. Additional management considerations include a dropping water table, the long-term impacts associated with the use of persistent pesticides and associated contamination, and increasing residential development, which results in parcelization, fragmented habitats, and the introduction of additional disturbances to the ecosystem.

The federal Conservation Reserve Program (CRP) as well as the federal Conservation Reserve Enhancement Program (CREP) have taken agricultural land out of row crop production and put it into permanent grassland cover in this area. However, original participation in these programs has been relatively low, as has the continuation of contracts after their initial expiration. Throughout Wisconsin, as well as in many other states, there is concern that many of these acres now in grass may be converted to row crop agriculture when the CRP contracts expire due to rising prices for corn and soybeans. Many of the acres recently in grass were converted to row crop production since 2008 (D. Sample, Wisconsin DNR, personal communication). There is a state program, the Central Wisconsin Grassland Conservation Area, that is trying to acquire and/or buy easements to establish additional grasslands in the area.

Management Opportunities, Needs, and Actions

- Increase the amount of open land where conditions are appropriate and conservation opportunities good. An overarching need is to maintain or increase the amount of "open" landscape, which must include a significant acreage of permanent grassy cover that includes patches large enough to sustain populations of area-sensitive species and minimal fragmentation from scattered patches of forest (often these are conifer plantations), roads, fences, ditches, or other developments. In the short-term, some of these developments are most problematic when they are lined with trees, but even fences have proven to constitute hazards for some species, including the Greater Prairie-Chicken.
- Sample and Mossman (1997) recommended adding an additional 37,500–112,500 acres of grassland in the "Central Plains Natural Division" of Hole and Germain (1994). The Wisconsin Greater Prairie-Chicken Management Plan 2004–2014 recommended adding an additional 28,000 acres to the Greater Prairie-Chicken range in Wisconsin over the long-term, with 15,000 acres as a 10-year goal. However, only about 2,000 of these acres would be added in the Central Sand Plains Ecological Landscape.
- Address patterns of ownership and management to benefit area-sensitive grassland birds. Maintaining large blocks of habitat that meet the needs of the area-sensitive grassland birds may become increasingly difficult as parcelization increases. Birds are more mobile than most taxa, but the present "checkerboard" pattern of lands in conservation management and permanent grass cover is not ideal for grassland birds or most other organisms of management concern. The best way to succeed in this ecological landscape may be to establish Bird Conservation Areas and ensure that there are several large acreages of permanent grass cover.
- Major habitat management objectives include reducing woody cover and preventing the encroachment of shrubs and saplings on areas that are now herb dominated; increasing the functional size of open habitat patches; maintaining or creating an open aspect at the "landscape scale" (over thousands of acres); and connecting open patches to facilitate movement of grassland-associated species. Grassland management here now includes the use of prescribed fire, mechanical control of woody vegetation, and the selective use of herbicides.
- Because ecosystems dominated by nonnative plants are prevalent here, the approach to invasives monitoring and control differs somewhat on nonnative (surrogate) grasslands than it would on relatively intact natural communities composed mostly of native grassland plants. One concern would be to avoid favoring species that have the ability to disperse, spread, and overrun areas dominated by native grassland vegetation. Another would be to control invasive plants that have adverse impacts (through competition, because they alter ecosystem structure in ways that are not favorable to native grassland birds, or for other reasons) on some of the nonnative species that can and do play important roles in these ecosystems by providing suitable habitat for the grassland birds.
- Evaluate the ecological values and management potential of the surrogate grasslands west of the Yellow River. For example, Wazee Lake County Park on the Jackson County Forest southeast of Black River Falls occupies the site of an abandoned iron mine. While not nearly as extensive as the surrogate grasslands at Buena Vista and Leola Marsh Wildlife Areas, hundreds of acres are now in an open condition, and these support grassland birds such as Northern Harrier, Grasshopper Sparrow (*Ammodramus savannarum*), Vesper Sparrow, Eastern Meadowlark (*Sturnella magna*), Bobolink (*Dolichonyx oryzivorus*), and Eastern Bluebird. An excellent Pine Barrens site, Bauer-Brockway Barrens, is immediately to the west, and some of the lands to the north contain small patches of barrens flora within a matrix of jack pine and scrub oak-dominated dry forest.

The extensive "Battle Peatlands" site on the eastern edge of the Black River State Forest is not far to the northeast and features large areas of open peatland used by a number of grassland birds.

- The Wazee Lake area may have high potential for management at a large scale, across several administrative jurisdictions, and with a variety of public benefits (including diverse forms of recreation, timber products, and many ecological benefits).
- At some locations, commercial cranberry operations play a meaningful role in providing for the habitat needs of area sensitive grassland birds (including wetland species) and other specialists. Such opportunities should be identified and pursued because the public lands are not by themselves providing the habitat needed by all species to maintain viable populations.

Geological Features

Cambrian sandstones are the dominant bedrock types in the Central Sand Plains, though the distribution of exposures of these sandstones is localized. The most dramatic and distinctive settings in which rock is exposed in this ecological landscape are on and around the nearly level plain formerly occupied by Glacial Lake Wisconsin. Here, there are buttes, mesas, pinnacles, and chimneys, which may rise several hundred feet above the surrounding flatlands. These unique landforms are the eroded remnants of the mostly horizontally oriented sedimentary strata that formerly covered much of central Wisconsin.The flanks of these rock features consist of cliffs that can be tens of meters high. Most of these are dry, but at a few locations, the heavily shaded rock surface is moist to the touch and supports plants that require a more or less permanently moist substrate and protection from desiccation.

Due to their aesthetic qualities and unique attributes (no other Wisconsin landscape has a collection of geological features resembling these), several sites showcasing the colorful, sculpted sandstone bedrock have been acquired by public agencies and are now nominally protected. Examples include Mill Bluff State Park and Quincy Bluff and Wetlands State Natural Area.

This Cambrian sandstone pinnacle may have been an island in Glacial Lake Wisconsin. Mill Bluff State Park, Juneau County. Photo by Eric Epstein, Wisconsin DNR.

The other unusual setting in which bedrock exposures occur in the Central Sand Plains are in the narrow sandstone gorges carved by small high gradient tributaries of the Black and Wisconsin rivers. Several of these gorges occur in the vicinity of Wisconsin Dells (which is named after a riverine gorge on the river's main stem) and were apparently formed when Glacial Lake Wisconsin drained abruptly and catastrophically around 14,000 years ago. Dams on both the Wisconsin and Black rivers have led to the inundation of the lower stretches of several of the gorges. Some of the rock features above the large dam at Wisconsin Dells appear to be threatened by accelerated erosion caused by the waves created by swarms of passing powerboats during the summer. Eventually, these undercut cliffs will topple into the water, taking their populations of rare plants with them.

The gorges (canyons, gulches, and glens, in local parlance) contain stretches of moist or "weeping" cliffs because the porous sandstones are able to receive and transmit water from higher elevations. The ***narrow defiles*** are heavily shaded and perpetually humid (and may experience cold air drainage as a daily phenomenon). Eastern hemlock, disjunct from its usual more northerly range, is a locally dominant tree at several sites, accentuating the already unusual environmental conditions.

The bedrock features in the Central Sand Plains support many rare plants (including the Wisconsin endemic cliff cudweed) and several rare animals. Most of these rare species are bedrock specialists, and some of them are associated with no other habitat. Rocky blufftops with a sparse covering of trees may support understory plants adapted to our now greatly diminished prairie or savanna communities. At a few locations, small patches of Dry Prairie occur on the xeric uppermost slopes of sandstone bluffs. Colonies of nesting swallows occur on cliffs at several locations, and Turkey Vultures (*Cathartes aura*) may nest on cliffs in remote locations, either in caves, under overhangs, or within deep fissures.

Less prominent outcroppings of bedrock are sometimes present on the upper slopes of sandstone ridges and mounds where they form low cliffs or ledges. Linear stands of white, red, or jack pine sometimes mark these exposures and are visible from a great distance. Similar outcroppings may be found at many locations farther west in the Western Coulees and Ridges Ecological Landscape.

Small exposures of Precambrian bedrock occur at Necedah Mound, which is a reddish quartzite remnant; at several locations along the Black River and its main tributary, the East Fork of the Black, where metamorphic gneisses are visible in these streams as rapids (the "falls" at Black River Falls is Precambrian ***gneiss***); and very locally, along the banks. Though Precambrian rock exposures are minor features in the Central Sand Plains, rock-bottomed stretches of rivers can be important habitats for sensitive aquatic organisms, including rare species.

Management Opportunities, Needs, and Actions

- Limit, discourage, or prohibit activities that damage rock faces, blufftops, or areas known to harbor, or which are suspected of harboring, sensitive species. Management needs include the protection of sensitive bedrock features from activities such as rock climbing, trampling of vegetation, and possibly quarrying. The sandstones are very soft and easily damaged, even by a pocket knife or other small metal tool, an attribute that vandals and lovers discover very quickly. Trails should not be routed along the edge of a bluff or escarpment because such locations may support sensitive species, and developments of this sort may impact site hydrology or species movements.
- Conduct systematic surveys of exposed bedrock habitats statewide. Some of the most important taxa associated with these features (e.g., lichens, mosses, terrestrial invertebrates) have received little past attention from biologists, and therefore not much is known about their distribution, habitat requirements, and status. Based on current knowledge and the high number of rarities associated with bedrock habitats in central Wisconsin, rock features in the Central Sand Plains Ecological Landscape should be considered a high priority for additional biological survey work. Initially, inventory work might focus on specific rock types or geographic areas already known to support rare bedrock specialists.
- Develop maps of and management guidelines for important bedrock habits for use by managers, other agency staff, and NGOs.

Miscellaneous Rare Communities and Habitats

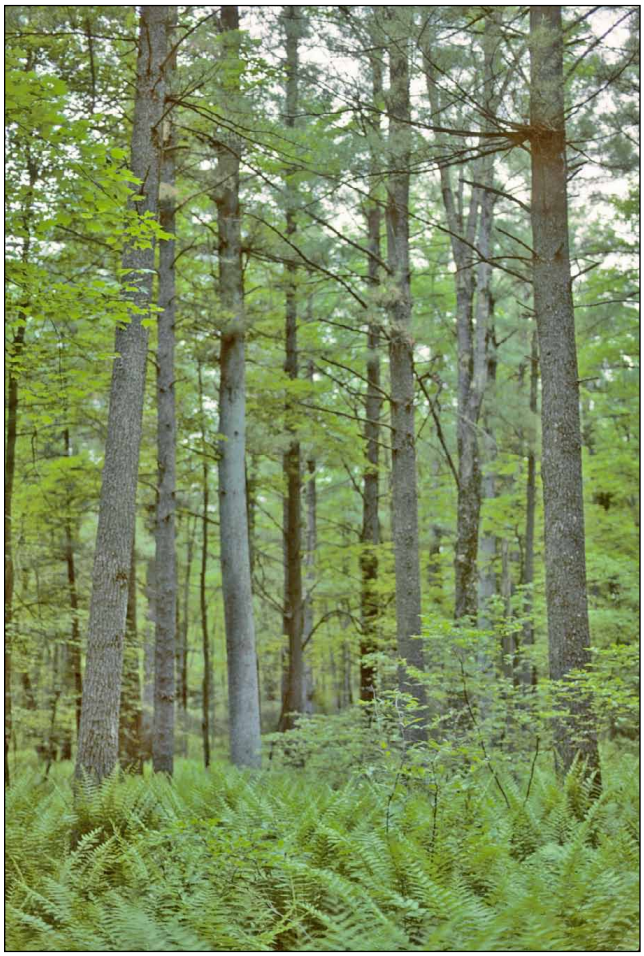
The examples given below are important because they represent rare and/or declining resources of limited geographic distribution, and they are known to occur in the Central Sand Plains. Other communities and habitats of documented value not covered in the other opportunities may also be considered for conservation and management attention.

Shallow sand-bottomed ponds and adjoining open wetlands are components of the rare Coastal Plain Marsh community. Jackson County. Photo by Eric Epstein, Wisconsin DNR.

White Pine-Red Maple Swamp

This wet-mesic forest community has high biodiversity values and occurs at few other locations in the state. The most extensive and best developed occurrences are concentrated in and around the bed of extinct Glacial Lake Wisconsin. Stands occupy the upper reaches of low gradient headwaters streams or occur as a zone of seepage-fed forest at the wetland-upland interface on the margins of some large peatlands. Soils are mucks or shallow peats over moist sand, and the high water table may be within 1 meter of the surface.

Mature, relatively undisturbed stands have especially high value as habitat for rare or otherwise sensitive animals, including Red-shouldered Hawk, Common Raven, Canada Warbler, Blackburnian Warbler, Blue-headed Vireo, Veery, and Winter Wren. White Pine-Red Maple Swamp is also the primary Wisconsin habitat for two rare and disjunct plant species, long sedge and Massachusetts fern (*Thelypteris simulata*).



White Pine-Red Maple Swamp is a rare forested wetland community that provides habitat for many plants and animals of conservation concern. Jay Creek Pines State Natural Area, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

Management Opportunities, Needs, and Actions

- Protect good, or restorable and potentially viable, examples of this natural community throughout its limited range. The most effective management strategy is to embed stands of this type within large blocks of other forest types, for example, with black spruce or tamarack swamps on the downslope side and xeric forests of mixed pine and oak on the upslope side. This increases habitat suitability for many forest interior species, especially those strongly associated with conifers.
- Because of the high water table and shallow rooting zone, this type is vulnerable to windthrow. To minimize this, use clearcutting sparingly, if at all, on adjoining forests.
- Protect the sensitive hydrology and fragile substrate of these sites. A hydrological attribute of this wet-mesic forest community is the presence of groundwater that moves laterally through the soil. Seepages, and sometimes spring runs, are often present. Because of the unusual site hydrology, the type is subject to severe rutting when heavy equipment is used to build roads or extract timber. During mild winters, or when deep persistent snows arrive early in the season, the ground may never freeze.
- Maintain high canopy closure to provide suitable habitat for rare species. Opening of the canopy reduces habitat value for some of the associated forest interior species, such as Red-shouldered Hawk, Northern Goshawk, Winter Wren, Blue-headed Vireo, and Blackburnian Warbler. Some stands near Black River Falls disturbed by ditching, road construction, and logging have been invaded by glossy buckthorn, a potentially serious threat to the regeneration of eastern white pine, some of the native shrubs, the rare disjunct herbs, and many of the ground-nesting animals.
- Develop better protection incentives for rare forest types and rare forest developmental stages. More effective incentives are needed to protect stands on private lands. Existing incentives promote commercial values, which can be at odds with protecting habitat for rare species and should not necessarily be the highest forest management priority.
- Wider recognition that this is a wetland community could address some of the management issues. White Pine-Red Maple Swamp should not simply be typed and managed as "white pine" (or "red maple," as some severely disturbed stands are typed). Many, if not most, mature stands will support sensitive species, and special care should be taken by managers to avoid soil compaction, rutting, stand isolation, disruption of hydrology (e.g., by channeling groundwater), and facilitating the spread of invasive plants.

Coastal Plain Marsh

In Wisconsin, Coastal Plain Marsh is a rare wetland community of limited geographic range characterized by zones of emergent aquatic macrophytes ringing a small softwater seepage pond. Water levels fluctuate periodically, which maintains habitat for a number of unusual plants, including several that are highly specialized and extremely rare, by setting back the growth of competing vegetation that would otherwise take over shoreline habitats where water levels are more stable. Coastal Plain Marsh occurs in poorly drained sandy areas, in some cases where fine-textured materials prevent the rapid drainage of water from the lakes or ponds. Surrounding lands may be near-level or gently sloping, with little topographic relief. The surrounding vegetation was historically either barrens or xeric pine or oak forest, providing management and protection opportunities often not present in the nearby Central Sand Hills Ecological Landscape where some of the occurrences are within agricultural lands and pastures, and trampling by livestock and degraded water quality due to excess inputs of sediments, nutrients, or herbicides can be serious problems.

A "surrogate" variant of this natural community occurs along rights-of-way in or around the bed of extinct Glacial Lake Wisconsin, where the water table is at or just beneath the surface, keeping the substrate saturated or partially inundated. Maintenance activities such as ditching, grading, or brush cutting can expose saturated sandy soils, which may be quickly colonized by an unusual floristic assemblage of Atlantic coastal plain disjuncts, prairie herbs, and fen plants. Several years without disturbance allows the rank, more generalized wetland vegetation that often occurs along rights-of-way in the Central Sand Plains to take over and become dominant. The conservation value of such surrogate habitats is uncertain because a change in maintenance methods may destroy or fail to maintain the unusual plants found in such sites. It's worth noting, however, that several such sites support very large populations of rare plants. These should be monitored.

Management Opportunities, Needs, and Actions

- Monitoring sites of both natural and human origin is a priority. On natural sites, this needs to be done across several cycles of high to low water. On ditches, around borrow pits, and in some rights-of-way, there is also a need to track short-term changes in the entire assemblage of plant species to see if any or all of them reappear as conditions change and disturbances occur.
- More rigorous protection for all Coastal Plain Marsh occurrences on public lands is warranted, and in some cases, badly needed. In recent years, both the natural and the human-created Coastal Plain Marsh habitats have proven vulnerable to serious damage by irresponsible use of off-road vehicles. The use of open shoreline areas as places upon which to operate or park mechanized logging equipment or deck logs should be avoided. This should never occur on public lands.
- Collect additional information on the dynamics and origin of the Coastal Plain Marsh community. Sites need to be monitored through entire cycles of high and low water. Groundwater withdrawals are a serious potential problem,

as is any use that would significantly disrupt natural site hydrology.

- Provide incentives, if new sites are located within lands used for agricultural or residential purposes, to assist landowners willing to protect these rare and fragile wetlands from water quality or physical degradation.

Sand Prairie

Sand Prairies are now rare here, but remnants are known from various rights-of-way and along roads, power lines, and railways. Though stands associated with such habitats are often small, isolated, and subject to disturbance from maintenance activities, they do provide repositories of native flora and may provide sources from which to aid in the restoration of damaged oak and pine barrens communities.

Some remnants are capable of supporting, at least for limited periods of time, populations of rare invertebrates, especially those closely associated with specific prairie plants. It would be useful, and undoubtedly instructive, to monitor such sites because their viability often seems questionable.

Management Opportunities, Needs, and Actions

- The locations of remnant Sand Prairies should be identified and mapped and the information conveyed to the appropriate management jurisdiction.
- Protect remnant prairies from inadvertent destruction by herbicide use, ill-timed mowing, grading, or other methods now used to keep rights-of-way in an open condition.
- Protect all native prairie habitats from tree planting.
- Establish plots or transects for baselines against which compositional and structural changes can be measured.
- Protect remnant prairies from destruction due to inappropriate use of recreational vehicles such as ATVs and snowmobiles.
- Identify suitable sites in the vicinity to which sensitive native plants and animals might be translocated. Develop criteria that will guide managers in prioritizing such activities because this can be labor intensive and expensive work.

Seeps

In the Central Sand Plains, spring seeps are limited to the bases or sandy slopes or sandstone bluffs. They are important as a source of cold, clean, oxygenated water for streams and rivers and sometimes provide habitat for rare or otherwise sensitive species.

Management Opportunities, Needs, and Actions

- Create maps that can be used by managers to incorporate management considerations for seeps into their management plans. Additional surveys to identify and assess seeps are needed along the Black River and some of its tributaries and also along the Wisconsin River near Wisconsin Dells.

Spring runs and seepages provide important microhabitats used by rare plants and animals. Black River State Forest, Jackson County. Photo by Eric Epstein, Wisconsin DNR.

- Avoid hydrologic disruption and mechanical disturbance (e.g., rutting) to seepage slopes.
- Maintain forest cover in seepage areas known to support or suspected of supporting sensitive species such as Louisiana Waterthrush (*Parkesia motacilla*) or bog bluegrass.

Scattered Populations of Rare Plants and Animals

There are populations of rare species in the Central Sand Plains that are not meaningfully associated with any of the features discussed more extensively above. The significance and management implications of these populations should be determined on a case-by-case basis, depending on factors such as state and global rarity, population size, site management potential and viability, number and distribution of protected populations elsewhere, and adequacy of survey information. State and federal laws may also impose constraints on how such populations are regarded, particularly if the species is listed as endangered or threatened.

Socioeconomic Conditions

Socioeconomic information for the Central Sand Plains Ecological Landscape is based on multiple-county approximations. The multi-county area used for this approximation is called the Central Sand Plains counties (Figure 10.10), except where otherwise noted. Economic data are available only on a political unit basis, generally with counties as the smallest unit. Demographic data are presented on a county approximation basis as well, since they are often closely associated with economic data. The counties included in this socioeconomic region are Adams, Clark, Jackson, Juneau, Monroe, Portage, and Wood since at least 25% of each county lies within the ecological landscape boundary. Small portions of Columbia, Eau Claire, Sauk, and Waushara counties are also in this ecological landscape, but no socioeconomic data from these counties are included in this chapter.

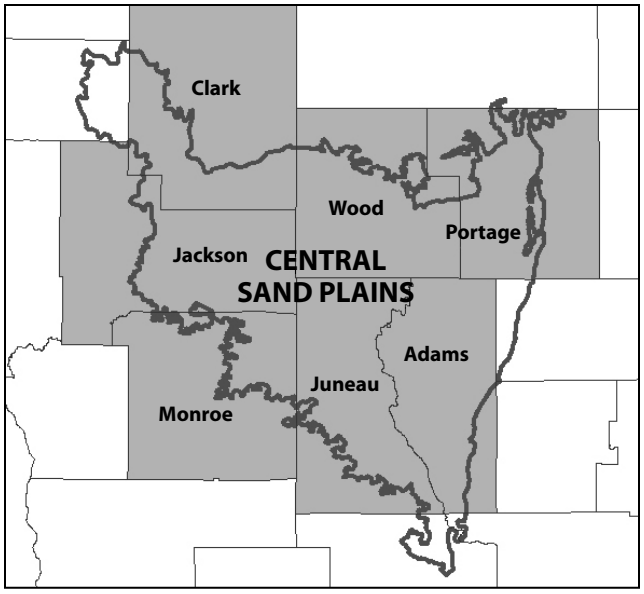


Figure 10.10. *Central Sand Plains counties.*

History of Human Settlement and Resource Use

American Indian Settlement

The Central Sand Plains Ecological Landscape generally had a lower prehistorical population than the ecological landscapes in the southern part of the state. While there is evidence of nearly continuous use, sites are more sporadic, and generally concentrated in river valleys where water and resources were more abundant (J.B. Stoltman, personal communication). Currently, there are no tribal reservations in the Central Sand Plains counties.

Historically, the Ho-Chunk people made their home in this region. The Ho-Chunk, called Winnebago by the French, were at Green Bay in the mid-1600s but had gradually moved inland to Lake Winnebago by 1700 (The Wisconsin Cartographers' Guild 1998). While 19th century treaties with the U.S. government forced the Ho-Chunk to cede all their Wisconsin lands, the population actually grew in the late 1800s due to returnees and today numbers over 6,500 (Ho-Chunk Nation 2010). For more information on the Ho-Chunk Nation and the history of human settlement and resource use in Wisconsin, see the "Statewide Socioeconomic Assessments" in Chapter 2, "Assessment of Current Conditions."

Euro-American Contact and Settlement

During the 17th century, French fur traders, soldiers, and missionaries began arriving in this region. As a result of contact with American Indian tribes, trading posts, missions, and forts along river routes and lakes were established. During the 1800s, however, American Indians ceded large chunks of land to the government, and permanent Euro-American settlement began in earnest. By 1860 Wisconsin was home to around 44,000 Norwegian settlers, and by 1870, 25% of these settlers lived in the area from Crawford to Barron County, including a portion of the Central Sand Plains region (The Wisconsin Cartographers' Guild 1998).

Early Agriculture

In 1850 the Central Sand Plains region contained 250 farms (ICPSR 2007). (The 1850 census was likely not entirely accurate since Adams County was shown to have more farms than people in 1850.) By 1860 the number of farms in Central Sand Plains counties had grown to 3,160 while the population had reached 38,563. By 1890 the region claimed 14,643 farms. Farm numbers continued to grow in Central Sand Plains counties, reaching 21,640 farms in 1920 (Figure 10.11). Central Sand Plains counties lost over 1,600 farms in the 1920s, with the onset of the depression driving marginal farmers out of production. Meanwhile, the population in Central Sand Plains counties continued to grow in all decades but the 1920s but fell behind statewide population growth. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," in Part 1 of the book for further discussion of the history of agricultural settlement in central Wisconsin.

During and following World War II, farm numbers again began to decline as mechanization and urbanization combined to increase the average size of farms. That trend continued throughout much of the remaining 20th century. Farms have tended to be larger on average in Central Sand Plains counties than in the state as a whole, averaging 149.6 acres in 1950 compared to 137.8 acres statewide (Figure 10.12).

Total value of all crops indicates the extreme influence of the Great Depression on agriculture. In 1910 all crops harvested in Central Sand Plains counties had an estimated total value of $12.1 million, which more than tripled by 1920 ($44.6 million) (ICPSR 2007). However, total value of all crops in Central Sand Plains counties plummeted in 1930 ($21 million) and fell further in 1940 ($14.1 million). Total values of crops in Central Sand Plains counties comprised only 8.4% of total crop value in the state in 1940 even though these crops came from farms comprising 11.9% of all Wisconsin farm acreage. Farms in Central Sand Plains counties historically have not been as productive as the state as a whole, perhaps in part because of fragile sandy soils, poor drainage, and growing season frosts.

Over the early part of the 20th century, the type of farming in Central Sand Plains counties underwent some fundamental shifts as the dairy industry was established as a leader in Wisconsin. The 1910 agricultural census listed "cereals" as 41.2% of the total value of all crops harvested in Central Sand Plains counties, but cereals comprised as little as 27.5% of total crop values in 1930, recovering only to 28.9% by 1940 (ICPSR 2007). Meanwhile, "hay and forage," associated with livestock farming, was only 32% of total value of crops harvested in Central Sand Plains counties in 1910 but had risen to 47.2% of total crop value by 1940. In Clark County, the

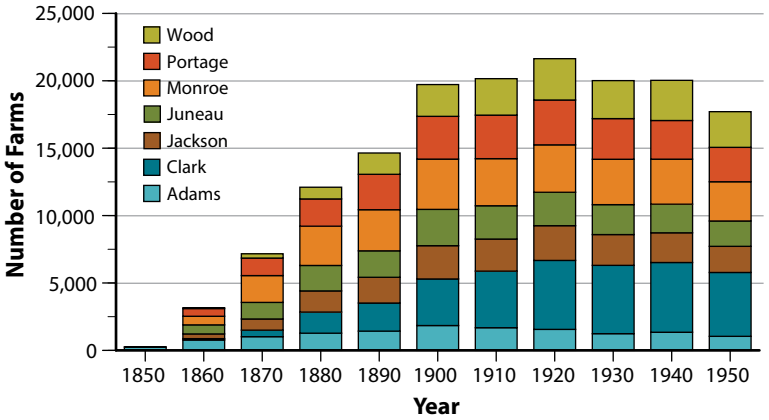


Figure 10.11. *Number of farms in Central Sand Plains counties between 1850 and 1950 (ICPSR 2007).*

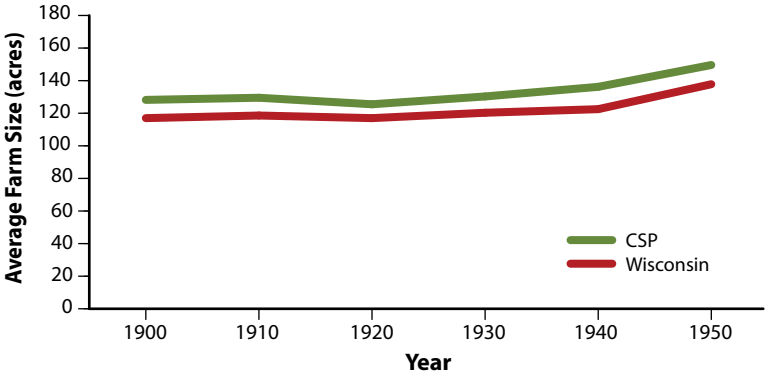


Figure 10.12. *Average farm size in Central Sand Plains counties between 1900 and 1950 (ICPSR 2007).*

leading agricultural Central Sand Plains county, crops had a total value of $3.2 million in 1940, 63% of which was from hay and forage.

Early Mining

Mining has occurred in Wisconsin for thousands of years. However, early mining was not important in the Central Sand Plains Ecological Landscape.

Early Transportation and Access

In 1673, Marquette and Jolliet established the first route across Wisconsin from Green Bay to the Mississippi River via the Fox and Wisconsin rivers. Early Euro-American settlers found an extensive network of Indian trails throughout the territory. With rapid Euro-American settlement following the end of the Black Hawk War in 1832, those trails were widened into roads suitable for ox carts and wagons (Davis 1947). A system of military roads was developed in Wisconsin around the same time, connecting key cities and forts with one another. By 1870, however, the importance of railroads had caused highways to become of secondary importance.

While a number of railroad lines ran through the Central Sand Plains region of the state, the region did not rely as heavily on railroad transportation as other areas of the state. Companies became more concerned with steam boat travel in this region. Locks were built near the Central Sand Plains Ecological Landscape on the lower Fox River (Central Lake Michigan Coastal Ecological Landscape), and a canal was constructed between the Fox and Wisconsin rivers (Central Sand Hills Ecological Landscape, just south of the Central Sand Plains Ecological Landscape) (The Wisconsin Cartographers' Guild 1998).

Railroad companies that operated in the Central Sand Plains region included the Port Edwards, Centralia, and Northern Railway Company, the Wisconsin, Pittsville, and Superior Railway Company, and the Milwaukee, Dexterville, and Northern Railway Company (Fisher 1937). See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," in Part 1 of the book for further discussion of the history of transportation in Wisconsin.

Early Logging Era

Sawmills were first built along rivers in areas containing large stands of timber. Where river conditions made it difficult to float logs, lumbermen built mills as close to the cutting area as possible, while on trouble-free rivers, sawmills were generally more centralized (Ostergren and Vale 1997). Wisconsin also had the advantage of an extensive network of waterways flowing south from the northern timber region. Wisconsin lumber production reached its peak at more than 4 billion board feet in 1892 (The Wisconsin Cartographers' Guild 1998). Sawmills caused towns to spring up all over the state. In the Central Sand Plains counties, Black River Falls was one of the major logging towns created by the industry. Sawmills in this region of the state harvested mainly stands of southern hardwood forest and pine savanna (The Wisconsin Cartographers' Guild 1998).

Roth (1898) described forest conditions in some of the northern Wisconsin counties at the close of the 19th century. (Adams, Juneau, and Monroe counties were not part of Roth's survey.) Roth noted that southern and western Clark County, associated with the sandy soils of the Central Sand Plains Ecological Landscape, grew pine with very little hardwood. Roth estimated the remnant pine stand at only 200 million board feet after being largely cut over. Hardwoods, especially oak, had been culled to a remaining stand of about 650 million board feet. Oak comprised 30% of the standing hardwoods, with the balance largely basswood and elm. Most of the county remained covered by culled hardwoods, much of it fire damaged. Clark County's vast pinery had largely disappeared in the wake of the Cutover and left "tracts of bare waste many miles in extent" (Roth 1898). By comparison, today there

are 286 million board feet of pine and 757 million board feet of hardwood sawtimber in Clark County forests (USFS 2009).

After considerable production of pine during the Cutover, Jackson County had an estimated 100 million board feet of pine species at the end of the 19th century (Roth 1898). The remaining bare expanses were beginning to regenerate in pine saplings and jack pine in the wake of repeated fires. Oak openings dominated the western half of Jackson County, but quality hardwoods only existed on patches of heavier soils and were not a component of the county's eastern pine and swamp forests. Jackson County swamps had formerly been stocked with tamarack and other wetland species but were decimated by the extensive fires. By comparison, today there are 462 million board feet of pine and 504 million board feet of hardwood sawtimber in Jackson County forests (USFS 2009).

Roth (1898) reported heavy cutting in most of Portage County's forests, both pine and hardwoods, leaving expansive tracts of burned over pine slash. Only 20 million board feet of pine were estimated to remain standing in isolated small pockets at the end of the 19th century. Yet to be harvested, jack pine forests were extensive and heavily stocked, especially in southwestern Portage County. Jack pine standing timber was estimated at 150 million board feet. By comparison, today there are 397 million board feet of pine, only 11 million board feet of hemlock, 355 million board feet of hardwood, and only 25 million board feet of jack pine sawtimber in Portage County forests (USFS 2009).

Wood County had been heavily cut over by the time of Roth's survey, and eastern white pine regeneration was already proceeding. Only an estimated 100 million board feet of pine remained in a county that had once been heavily stocked with eastern white pine to its north (much of it in the Forest Transition Ecological Landscape) and covered in mixed pine to the south (Roth 1898). Hardwoods had similarly been heavily harvested, with a remaining estimated stand volume of 300 million board feet on not more than 12% of the land area. More than half of Wood County hardwood volume was oak and basswood. By comparison, today there are 236 million board feet of pine, only 2 million board feet of hemlock, and 664 million board feet of hardwood sawtimber in Wood County forests (USFS 2009).

Resource Characterization and Use[1]

The Central Sand Plains Ecological Landscape has 3,420 square miles of total area, comprising 3,276 square miles of land and 144 square miles of open water. The proportion of surface water in relation to the total area of the ecological landscape is fourth highest out of the 16 ecological landscapes. Most "lakes" in this ecological landscape are impounded rivers and streams.

[1]When statistics are based on geophysical boundaries (using GIS mapping), the name of the ecological landscape is followed by the term "ecological landscape." When statistics are based on county delineation, the name of the ecological landscape is followed by the term "counties."

Several factors make recreation an important factor in the economy of the Central Sand Plains Ecological Landscape. This region has a high percentage of land in forest, wetlands, and water. In addition, the proportion of public land is quite high, especially state- and county-owned lands. Visitor numbers to state properties are high, and camping is an important recreational activity in these counties.

Agriculture and forestry are also important to the economy of the Central Sand Plains counties. The seven counties have a fairly high income per acre from farming, both from crop production and dairy. Timber growing stock volume is also fairly high and has increased substantially in the last decade, along with the amount of timber harvested, especially pine. Volume per acre, however, is low, reflecting soils with low productivity. The major forest types are oak-hickory and red, white, and jack pine.

This ecological landscape has a well-developed transportation system, especially air and rail transport, as well as the highest hydroelectric power generation in the state. There is potential for other renewable resources, including woody biomass and agriculture crop-based ethanol production.

The Land

Of the 2.1 million acres of land (not including the area of open water) that make up the Central Sand Plains Ecological Landscape, 60% is forested. About 58% of all forested land is privately owned while 36% belongs to the state, counties, or municipalities, and 6% is federally owned (USFS 2009).

Minerals

Four of the seven Central Sand Plains counties were engaged in some type of nonmetallic mineral extraction in 2007. Clark and Portage counties had crushed and broken granite mining and quarrying operations, Wood County produced dimension stone and kaolin and ball clay, and Jackson County produced industrial sand (USCB 2010). Frac sand mining is increasing dramatically in some areas of Wisconsin due to its increased use in oil and gas extraction. As of December 2011, there were four frac sand mining or processing plants active or in development in the Central Sand Plains Ecological Landscape.

Water (Ground and Surface)

Water Supply

The data in this section are based on the Wisconsin DNR's 24K Hydrography Geodatabase (Wisconsin DNR 2012a), which are the same as the data reported in the "Hydrology" section of this chapter; however, the data are categorized differently here so the numbers will differ slightly. Surface water covers over 92,000 acres in the Central Sand Plains Ecological Landscape, or 4.2% of the total area. There are over 1,868 lakes or impoundments that are at least 1 acre in size, totaling approximately 72,000 acres or 78% of total surface water. Eight lakes cover over 500 acres, and three are over 1,000 acres in size: Petenwell Flowage (23,000 acres), Castle Rock

Flowage (more than 12,000 acres), and the Wisconsin River Flowage (2,500 acres). There are 428 dams impounding over 69,000 acres of water (Wisconsin DNR 2012a). Most of the surface waters in the Central Sand Plains Ecological Landscape are in impoundments. There are approximately 15,500 acres of streams and rivers, of which the Wisconsin, Black, Lemonweir, and Yellow rivers are the largest and longest.

Water Use

Each day 274.5 million gallons of ground and surface water are withdrawn in the seven Central Sand Plains counties (Table 10.4). About 71% of the withdrawals are from surface water. Of the 292,119 people that reside in these counties, 48% are served by public water sources and 52% are served by private wells (USGS 2009). Portage and Adams counties have the largest irrigation withdrawals, mostly from groundwater wells. Wood County uses the most water (44% of the total), 92% of which is for industrial use. Most of this is from surface water sources.

Recreation

Recreation Resources

Land use, land cover, and ownership patterns will partly determine the type of recreation that is available to the public. For instance, in the Central Sand Plains Ecological Landscape, there is proportionally 31% more forest and 25% less agricultural land compared to the rest of the state (see Chapter 3 of the book, "Comparison of Ecological Landscapes," and/or the map entitled "WISCLAND Land Cover (1992) of the Central Sand Plains Ecological Landscape" in Appendix 10.K at the end of this chapter).

The percentage of surface area in water is fourth highest in the state. The Central Sand Plains Ecological Landscape has far more public land in general than other parts of southern Wisconsin. The density of campgrounds is higher than average as is the number of visitors to state lands. Trail density, however, is quite low compared to other ecological landscapes. Acreage in natural areas is much higher than average, but the number of Land Legacy sites with high recreation potential is low.

Supply

Land and Water. The Central Sand Plains Ecological Landscape accounts for 6.1% of the state's land area (see Chapter 3, "Comparison of Ecological Landscapes," in Part 1 of the book) and 7.2% of the state's acreage in water. Rivers make up 17%, lakes larger than 1 acre in size account for 78%, and lakes and ponds smaller than 1 acre make up the remaining 5% of all surface water in the ecological landscape (Wisconsin DNR 2012a). Important recreational waters include the Wisconsin, Black, Lemonweir, and Yellow rivers as well as Petenwell Flowage, Castle Rock Flowage, and the Wisconsin River Flowage (Wisconsin DNR 2006b).

Public Lands. Public access to recreational lands is vital to all types of recreational activity. In the Central Sand Plains Ecological Landscape, 655,200 acres, or 29.9% of the area in land and water, is publicly owned. This is higher than the statewide average of 19.5% and ranks sixth (out of 16 ecological landscapes) in the proportion of public ownership. There are about 184,300 acres of state lands, 39,450 acres of federal lands, and 339,200 acres of county lands. Surface water adds another 92,000 acres. Of the 1.25 million acres of forestland in the Central Sand Plains Ecological Landscape (based on FIA data; USFS 2007), 42% is in public ownership (USFS 2009).

State-owned facilities are especially important to recreation in the Central Sand Plains Ecological Landscape. The Black River State Forest provides 67,000 acres for nature and water-based recreation along with many miles of multipurpose trails (a very small part of this state forest is in the Western Coulees and Ridges Ecological Landscape). There are over 8,000 acres in parks and recreation areas, including Buckhorn State Park, Mirror Lake State Park, Roche-a-Cri State Park, Rocky Arbor State Park, and part of Mill Bluff State Park. In addition, there are 983 acres of state trails and state Wild Rivers and approximately 95,000 acres of State Fisheries and Wildlife Management Areas. The largest of these are state wildlife areas, including Meadow Valley, Sandhill, Buena Vista, Dewey Marsh, and Colburn Wildlife Areas. Each provides over 5,000 acres of recreational land (Wisconsin DNR 2005a).

Table 10.4. *Water use (millions of gallons/day) in the Central Sand Plains counties.*

County	Groundwater	Surface water	Domestic[a]	Agriculture[b]	Irrigation	Industrial	Commercial	Thermo-electric	Loss	Total
Adams	38.2	0.0	1.0	0.1	36.7	0.2	0.2	0.0	0.1	38.2
Clark	4.9	0.2	1.7	2.2	0.0	0.5	0.3	0.0	0.4	5.1
Jackson	9.3	0.1	1.0	0.6	0.0	0.4	0.2	0.0	0.3	9.4
Juneau	8.3	0.0	1.2	0.4	5.6	0.3	0.3	0.0	0.5	8.3
Monroe	6.2	0.1	2.0	1.2	0.1	0.8	1.2	0.0	1.1	6.4
Portage	77.6	7.7	3.3	0.6	57.6	18.0	2.2	0.0	2.7	85.3
Wood	11.1	110.7	3.5	1.8	1.3	112.3	1.4	0.0	1.6	121.8
Total	**155.6**	**118.8**	**13.7**	**6.9**	**101.3**	**132.5**	**5.8**	**0.0**	**6.7**	**274.5**

Source: Based on 2005 data from the U.S. Geological Survey on water uses in Wisconsin counties (USGS 2009).
[a]Domestic self-supply wells.
[b]Includes aquaculture and water for livestock.

A central Wisconsin jack pine barrens with scattered openings supporting dense patches of wild lupine. Adams County, 1990. Photo by Eric Epstein, Wisconsin DNR.

Roche-A-Cri, an isolated butte composed of Cambrian sandstone, was once an island in Glacial Lake Wisconsin. This bedrock feature rises abruptly from the nearly level surface of the Central Sand Plains in Adams County. Photo by Wisconsin DNR staff.

Visitors to State Lands. There are 82 public and privately owned campgrounds that provide about 8,114 campsites in the Central Sand Plains counties (Wisconsin DNR 2006b). This ecological landscape ranks fifth (out of 16 ecological landscapes) in the number of campgrounds (7% of the state's campgrounds) and sixth in campground density (campgrounds per square mile of land) compared to other ecological landscapes.

Trails. There are abundant multipurpose trails within the Central Sand Plains counties (Table 10.5), totaling over 3,120 miles. However, these counties rank 12th (out of 16 ecological landscapes) in trail density (miles per 100 square miles). There is a lower density of hiking, road biking, ATV, and snowmobiling trails compared to the rest of the state.

Land Legacy Sites. The Land Legacy project has identified over 300 places of significant ecological and recreational importance in Wisconsin, and 16 of these "legacy places" are either located or partially located within the Central Sand Plains

Sandhill cranes are primarily birds of open fresh water wetlands but also use habitats that range from bogs, sedge meadows, and fens to open grasslands, savannas, and cultivated lands. Sandhill Wildlife Area, Wood County. Photo by Wisconsin DNR staff.

Ecological Landscape (Wisconsin DNR 2006c). Of these, the middle Wisconsin River is rated as having the highest recreation potential. Nine sites are categorized as having the highest conservation significance: Bear Bluff, Black River, Central Wisconsin Forests, Central Wisconsin Grasslands, Necedah National Wildlife Refuge, Quincy Bluff and Wetlands, Robinson Creek Barrens, Sandhill-Meadow Valley-Wood County Wildlife Areas, and the Yellow (Juneau County) River.

State Natural Areas. In addition, there are 32,600 acres of State Natural Areas (either partially or totally located within the Central Sand Plains Ecological Landscape), of which 95% is owned exclusively by the public (including government and educational institutions), and 5% is owned by joint public-private interests (including NGOs). The largest State Natural Areas in this ecological landscape are Quincy Bluff and Wetlands (6,433 acres, Adams County), Suk Cerney Peatlands (3,611 acres, Juneau County), Deer Island (2,121 acres, Jackson County), Buckhorn Barrens (1,679 acres, Juneau County), and upper Black River (1,533 acres, Jackson County) (Wisconsin DNR unpublished data; for more information regarding State Natural Areas, see Wisconsin DNR 2013c).

Demand

Visitors to State Lands. In 2004 there were an estimated 644,000 visitors to state recreation areas, state parks, and state forests in the Central Sand Plains Ecological Landscape. The majority visited state parks, especially Mirror Lake State Park, which accounted for 52% of the total (Wisconsin DNR 2006b).

Fishing and Hunting License Sales. Of all license sales, the highest revenue producers for the Central Sand Plains counties were resident hunting licenses (53% of total sales), resident fishing licenses (26% of total sales), and nonresident fishing licenses (10% of total sales) (Wisconsin DNR, unpublished data). Table 10.6 shows a breakdown of various licenses sold in the Central Sand Plains counties in 2007. Wood County sells the most licenses and brings in the most revenue. This ecological landscape county approximation accounts for about 5% of total license sales in the state. However, persons buying licenses in the Central Sand Plains counties may travel to other parts of the state to use them.

Metropolitan Versus Nonmetropolitan Recreation Counties. A research study (Johnson and Beale (2002) classified Wisconsin counties according to their dominant characteristics. One classification is "nonmetro recreation county." This type of county is characterized by high levels of tourism, recreation, entertainment, and seasonal housing. Two of the Central Sand Plains counties are classified as nonmetro recreation counties: Adams and Juneau counties.

Recreational Issues

Certain issues are causing impediments to outdoor recreation opportunities within Wisconsin. Many of these issues, such as increasing ATV usage, overcrowding, increasing multiple-use recreation conflicts, loss of public access to lands and waters, invasive species, and poor water quality, are common across many regions of the state.

Silent Sports Versus Motorized Sports. Over the next decade, the most dominant recreation management issues will most likely revolve around conflicts between motorized and nonmotorized recreation interests. From a silent-sport perspective, noise pollution from motorized users is one of the higher causes for recreation conflict (Wisconsin DNR 2006b). Recreational motorized vehicles include snowmobiles, ATVs, motor boats, and jet skis. ATV use is especially contentious. ATV riding has been one of the fastest growing outdoor recreational activities in Wisconsin. Many ATV riders feel there is a lack of ATV trails, and they are looking primarily to public lands for places to expand their riding opportunities.

Timber Harvesting. A high percentage of people are concerned about timber harvesting in areas where they recreate (Wisconsin DNR 2006b). Their greatest concern about timber harvesting is that it not disturb their recreational activities. They are most opposed to large-scale visual changes (e.g., openings) in the forest landscape. Forest thinning and harvesting that creates small openings are more acceptable. Silent-sport enthusiasts (e.g., hikers, bird watchers) as a group are the most concerned about the visual impacts of harvesting, while hunters and motorized users are somewhat less concerned.

Table 10.5. *Miles of trails and trail density in the Central Sand Plains counties compared to the whole state.*

Trail type	Central Sand Plains counties (miles)	Central Sand Plains counties (miles/100 mi^2)	Wisconsin (miles/100 mi^2)
Hiking	155	2.5	2.8
Road biking	275	4.5	4.8
Mountain biking	133	2.2	1.9
ATV, summer & winter	425	7.0	9.3
Cross-country skiing	300	4.9	7.2
Snowmobile	1,832	30.0	31.2

Source: Wisconsin Department of Natural Resources unpublished data.

Table 10.6. *Fishing and hunting licenses and stamps sold in the Central Sand Plains counties, 2007.*

County	Resident fishing	Nonresident fishing	Miscellaneous fishing	Resident hunting	Nonresident hunting	Stamps	Total
Portage	16,109	1,355	433	24,271	397	7,328	49,893
Adams	6,218	5,235	134	5,512	249	1,492	18,840
Clark	4,355	271	112	11,119	192	1,680	17,729
Jackson	4,642	823	157	9,789	357	2,791	18,559
Juneau	5,464	3,724	260	8,190	363	2,335	20,336
Monroe	8,475	952	275	17,265	394	5,456	32,817
Wood	17,140	1,314	737	33,577	261	6,834	59,863
Total	**62,403**	**13,674**	**2,108**	**109,723**	**2,213**	**27,916**	**218,037**
Sales ($)	**$1,420,650**	**$559,193**	**$44,335**	**$2,922,148**	**$321,677**	**$221,264**	**$5,489,267**

Source: Wisconsin Department of Natural Resources unpublished data, 2007.

Loss of Access to Lands and Waters. With the ever-increasing development along shorelines and continued fragmentation of forestlands, there has been a loss of easy access to lands and waters within this ecological landscape. This may come from the fact that housing developments have become more concentrated with the advent of condominium developments that have closed large areas of shoreline once open to the casual recreation user. Another element that may also play into the idea of lost access is the lack of information about where to go. This element is also high on the list of barriers for increased outdoor recreation (Wisconsin DNR 2006b).

Agriculture

Farm numbers in the Central Sand Plains counties have decreased 27% since 1970 (USDA NASS 2004). There were approximately 11,780 farms in 1970 and 8,576 in 2002. Between 1970 and 2002, average farm size increased from 200 acres to 235 acres, which is much higher than the statewide average of 204 acres in 2002. The overall land in farms has steadily decreased since the 1970s (Figure 10.13). In 1970, there were about 2.2 million acres of farmland, and by 2002, acreage was down to 1.9 million acres, a decrease of 15%. The Central Sand Plains counties actually had one of the lowest farmland conversion rates in the state.

The seven counties have between 28% and 61% of their land area in farms. Monroe, Clark, and Portage counties have the highest percentage, over 50%. Much of the marginal farmland in Wisconsin is reverting to forest or grassland as new absentee landowners use the land for purposes other than agriculture.

Agriculture is an important part of the economy of the Central Sand Plains counties. In 2002, net cash farm income totaled $178 million, or an average of $94 per acre, about the same as the statewide average of $91 per acre (USDA NASS 2004). Clark County had the second highest net cash farm income and the highest number of dairy cows. Portage and Adams counties ranked very high in income from crops. Also in 2002, the market value of all agriculture products sold in the Central Sand Plains counties was $670 million (8% of state total); 42% of this amount came from crop sales, while the remaining 58% was from livestock sales. Some of these counties are top crop producers in the state. The Central Sand Plains counties combined produce half the state's potatoes. Jackson and Wood counties are the top cranberry producers in the state.

In 2007, 18,446 acres of farmland had been sold, of which 92% stayed in agricultural use at an average selling price of $2,643, and only 8% was diverted to other uses (USDA NASS 2009).

Timber

Timber Supply

Based on 2007 Forest Inventory and Analysis (FIA) data, 60% (approximately 1,250,800 acres) of the total land area for the Central Sand Plains Ecological Landscape is forested (USFS 2007). This is 7.6% of Wisconsin's total forestland acreage. ***Forestland*** is defined by FIA as any land with more than 17% canopy cover. (This definition is used for certain economic applications but is not generally used by ecologists.)

Timber Ownership. ***Timberland*** is defined as forestland capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization. Of all timberland within the ecological landscape, 58% is owned by private landowners (USFS 2009; Figure 10.14). Of the remaining timberland, 36% is owned by state and local governments, and 6% is federally owned.

Growing Stock and Sawtimber Volume. There were approximately 1.3 billion cubic feet of growing stock volume in the Central Sand Plains Ecological Landscape in 2007, or 6.3% of total volume in the state (USFS 2009).

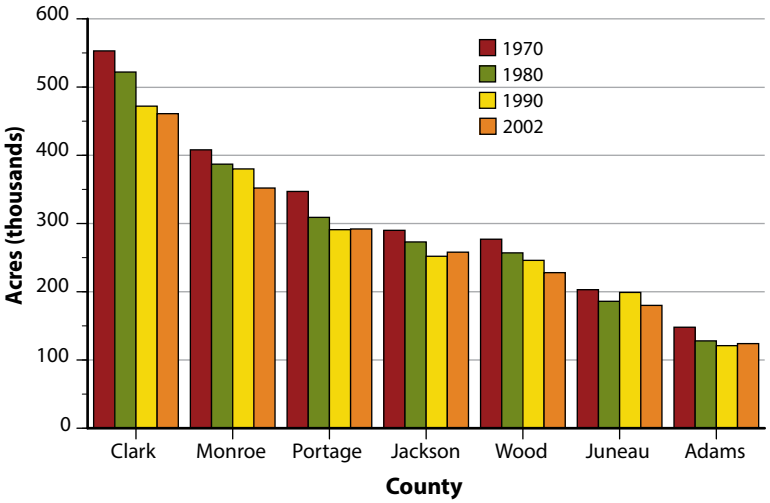


Figure 10.13. *Acreage of farmland by county and year (USDA NASS 2004).*

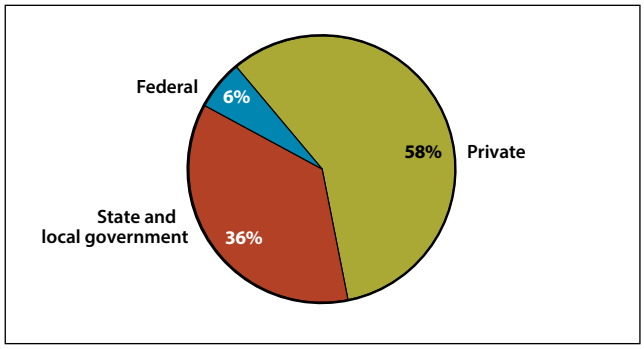


Figure 10.14. *Acreage of timberland by owner group (USFS 2009).*

Most of this volume, 62%, was in hardwoods, which made up a lower proportion of the sawtimber volume, 55%, in the Central Sand Plains Ecological Landscape. In comparison, for the whole state, sawtimber hardwood volume was 67% of total volume.

Annual Growing Stock and Sawtimber Growth. Between 1996 and 2007, the Central Sand Plains Ecological Landscape timber resource increased by 214 million cubic feet or 20% (USFS 2007). Most of this increase, 77%, occurred in softwood volume. Sawtimber volume increased by 1.2 billion board feet or 46%. Most of this change, 61%, occurred in softwood volume. Timberland acreage increased slightly from 1,237,820 to 1,245,839 acres between 1996 and 2007.

Timber Forest Types. According to FIA data (USFS 2009), the predominant forest type groups (see Appendix H, "Forest types That Were Combined into Forest Type Groups Based on Forest Inventory and Analysis (FIA) Data," in Part 3 of the book ("Supporting Materials") in terms of acreage are oak-hickory (34%); white, red, and jack pine (26%) (most of the red pine acreage is in plantations); and smaller amounts of oak-pine, aspen-birch, and maple-basswood. Acreage is fairly equally distributed between the sawtimber, pole, and seedling/ sapling size classes, (37%, 33%, and 30%, respectively; see Table 10.7).

Timber Demand

Removals from Growing Stock. The Central Sand Plains Ecological Landscape has about 6.3% of the total growing stock volume on timberland in Wisconsin (see the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes," in Part 1). Average annual removals from growing stock for the Central Sand Plains were 30 million cubic feet, or about 9% of total statewide removals (349 million cubic feet) between 2000 and 2002 and between 2005 and 2007 (USFS 2009). Average annual removals to growth ratios vary by species, as can be seen in Figure 10.15 (only major species are shown). Removals exceed growth for quaking aspen (*Populus tremuloides*) and big-tooth aspen (*Populus grandidentata*), white and northern red oak, and white birch.

Removals from Sawtimber. The Central Sand Plains Ecological Landscape has about 6.4% of the total sawtimber volume on timberland in Wisconsin. Average annual removals from sawtimber for the ecological landscape were over 75 million board feet, or 7.2% of total statewide removals (1.1 billion board feet) between 2000 and 2002 and 2005 and 2007 (USFS 2009). Average annual removals to growth ratios indicate that removals exceeded growth for bigtooth aspen (Figure 10.16), which is to be expected since this a ***pioneer species*** and harvested primarily for pulp.

Price Trends

In the Central Sand Plains counties, sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), and northern red oak were the highest priced hardwood sawtimber species in 2007, receiving approximately $425, $400, and $338 per thousand board feet (MBF), respectively (Wisconsin DNR 2008). Eastern white pine and red pine were the most valuable softwood timber species at $172/MBF and $155/MBF, respectively. Sawtimber prices for 2007 were generally lower for hardwoods and higher for softwoods compared to the rest of the state.

For pulpwood, sugar maple is the most valuable with a price of $42 per cord (Wisconsin DNR 2008); however, there is very little sugar maple pulpwood harvested in the Central Sand Plains counties compared with red and eastern white

Table 10.7. *Acreage of timberland in the Central Sand Plains Ecological Landscape by forest type and stand size class.*

Forest type[a]	Seedling/sapling	Pole-size	Sawtimber	Total
Aspen	63,621	14,453	75,257	153,330
Eastern white pine	13,162	59,465	29,949	102,576
Elm-ash-cottonwood group	14,354	21,541	34,640	70,536
Jack pine	54,888	12,169	39,983	107,040
Maple-beech-birch group	6,826	7,936	10,761	25,522
Oak-hickory group	105,755	133,349	208,645	447,749
Oak-pine group	38,952	55,595	74,905	169,452
White birch	7,171	3,142	3,777	14,090
Red pine	43,594	37,983	22,085	103,662
Spruce-fir group	28,797			28,797
Nonstocked[b]				6,336
Total	**365,734**	**400,856**	**456,163**	**1,229,090**

Source: U.S. Forest Service Forest Inventory and Analysis (USFS 2009).

[a]U.S. Forest Service Forest Inventory and Analysis (FIA) uses a national forest typing system to classify FIA forest types from plot and tree list samples. Because FIA is a national program, some of the national forest types in the above table do not exactly represent forest types that occur in Wisconsin. For example, neither post oak nor blackjack oak occur to any great extent in Wisconsin, but since there is no "black oak forest type" in the FIA system, black oak stands in Wisconsin were placed in the "post oak-blackjack oak" category.

[b]Nonstocked land is less than 16.7% stocked with trees and not categorized as to forest type or size class.

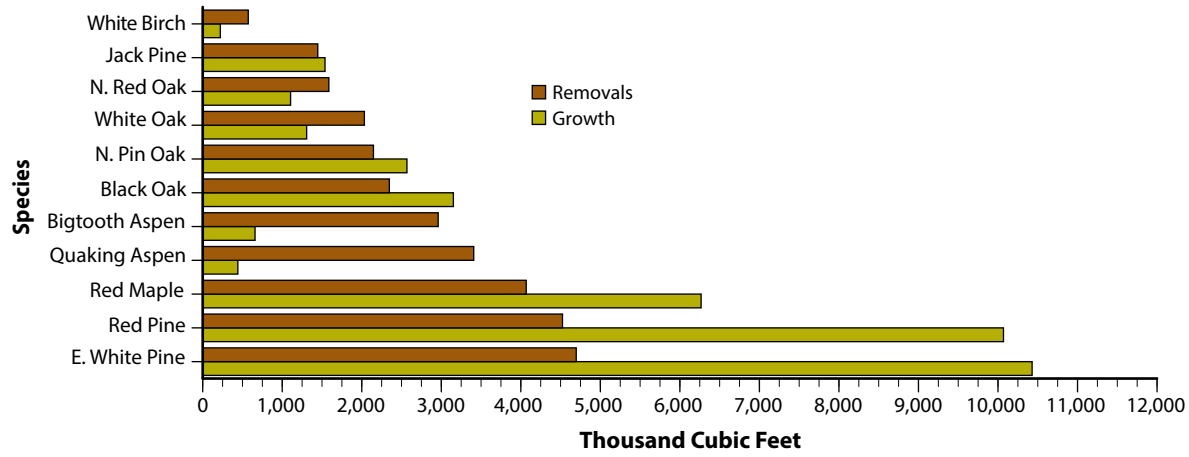


Figure 10.15. *Growing stock growth and removals (selected species) on timberland in the Central Sand Plains Ecological Landscape, 2007 (USFS 2009).*

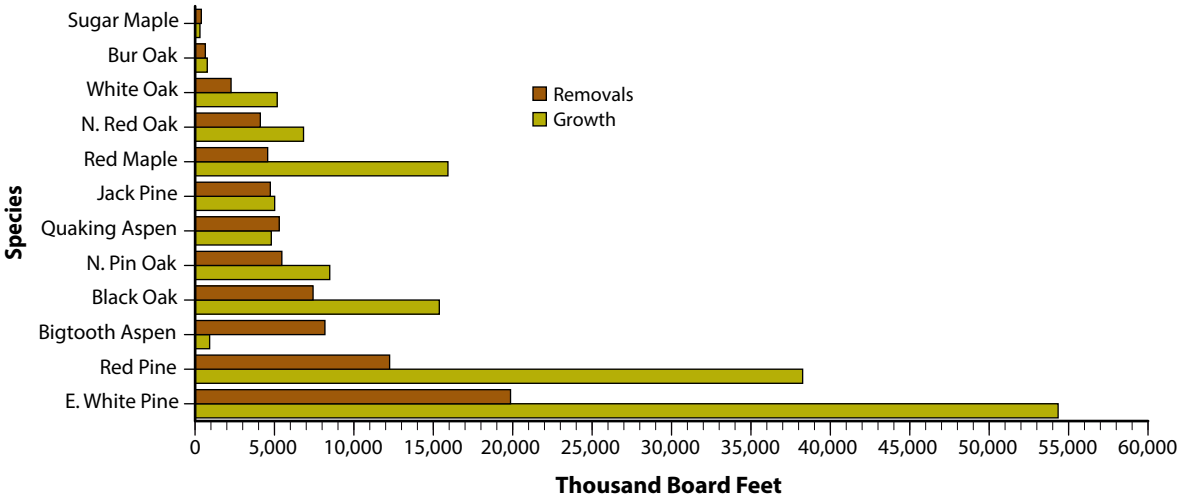


Figure 10.16. *Sawtimber growth and removals (selected species) on timberland in the Central Sand Plains Ecological Landscape, 2007 (USFS 2009).*

pine, aspen, and red maple. The increase in aspen and red maple pulpwood harvests is a result of the paper industry in the region changing from softwood to hardwood raw material. Pulpwood values in the Central Sand Plains counties were lower for softwoods and higher for hardwoods compared to the statewide average.

Infrastructure

Transportation

The transportation infrastructure of the Central Sand Plains Ecological Landscape is somewhat more developed than the rest of the state. Although road mile density is only 3% lower (Wisconsin DOA 2000), railroad density is 16% higher (Wisconsin DOT 1998), and runway density is 12% higher than the state as a whole (Wisconsin DOT 2012). There are eight airports in the Central Sand Plains Ecological Landscape, none of which are primary regional airports, and there are no shipping ports (Table 10.8).

Renewable Energy

Hydroelectric and wind turbine power are the only renewable energy sources quantified by county in Wisconsin (Wisconsin DOA 2006). Some general inferences can be drawn from other sources regarding the potential for renewable energy production in the Central Sand Plains counties.

The Central Sand Plains Ecological Landscape has the potential to produce a significant amount of renewable energy, especially woody biomass, hydroelectric, and agricultural crop-based ethanol. It has 6.3% of all woody biomass in Wisconsin, generates 21.9% of hydroelectric power, and produces 5.8% of the state's corn crop (Wisconsin DOA 2006). This ecological landscape does not have any ethanol plants or wind generating sites.

Biomass. Woody biomass is Wisconsin's most used renewable energy resource. The Central Sand Plains counties produce 17 million cubic feet of logging residue, or 11% of total

Table 10.8. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports in the Central Sand Plains Ecological Landscape.*

	Central Sand Plains	State total	% of state total
Total road length (miles)[a]	10,921	185,487	6%
Road density[b]	3.3	3.4	–
Miles of railroads	368	5,232	7%
Railroad density[c]	11.2	9.7	–
Airports	8	128	6%
Miles of runway	6.5	95.7	7%
Runway density[d]	2.0	1.8	–
Total land area (square miles)	3,276	54,087	6%
Number of ports[e]	0	14.0	0%

[a]Includes primary and secondary highways, roads, and urban streets.
[b]Miles of road per square mile of land. Data from Wisconsin Roads 2000 TIGER line files (dataset) (Wisconsin DOA 2000).
[c]Miles of railroad per 100 square miles of land. Data from 1:100,000-scale Rails Chain Database (Wisconsin DOT 1998).
[d]Miles of airport runway per 1,000 square miles of land. Data from Wisconsin Airport Directory 2011–2012 web page (Wisconsin DOT 2012).
[e]Data from Wisconsin Commercial Ports Association (WCPA 2010).

statewide production (USFS 2007). Approximately 60% of the land base is forested. This has increased by 1% in the last decade.

Hydroelectric. There are nine hydroelectric power sites in this ecological landscape that generate 317.5 million kilowatt hours (kWh), or 21% of the state total (Wisconsin DOA 2006). In the entire state, there are 68 sites (owned either by utility companies or privately owned) with a total generation of 1,462 million kWh.

Ethanol. The Central Sand Plains counties produce 34.5 million bushels of corn, or 5.5% of total production in the state (USDA NASS 2004). Acreage in agriculture currently makes up 47% of the land base in the Central Sand Plains counties but has decreased by 15% between 1970 and 2002. If this trend continues, increasing ethanol production will depend on converting land to corn. There were no ethanol plants located in the Central Sand Plains counties in 2006.

Wind. There are no currently sited or proposed wind farms in the Central Sand Plains Ecological Landscape (WWIC 2013). Mean annual wind power densities are generally below 100 W/m^2 in this part of the state, indicating that there is little potential for wind generation (USDE 2013).

Current Socioeconomic Conditions

The Central Sand Plains Ecological Landscape is composed of seven largely rural counties: Adams, Clark, Jackson, Juneau, Monroe, Portage, and Wood.

Demography

Central Sand Plains counties are rural in character, with many small cities and towns. Population density and housing density are typical of rural Wisconsin counties, although property values are among the lowest on average among ecological landscapes in the state. In general, the region is homogeneous in racial structure and exhibits an age distribution only slightly skewed towards an older population. Education attainment in Central Sand Plains counties is lower than statewide averages.

Population Distribution

The combined population of the Central Sand Plains counties in 2010 was 292,119 (USCB 2012b). These counties were classified as mostly rural (58%) (higher percentage of county residents live outside population centers of 2,500 or more) by the Census Bureau but to varying degrees among Central Sand Plains counties (USCB 2009). Adams County is classified as entirely rural and contains the smallest population among Central Sand Plains counties. Portage (38%) and Wood counties (37%) have rural proportions much closer to statewide rural composition (32%) and contain roughly half of the total population of Central Sand Plains counties.

According to 2007 U.S. Census Bureau estimates, population centers (defined by the U.S. Census Bureau as cities with population over 2,500) within Central Sand Plains counties include the cities of Stevens Point (population 24,849), Wisconsin Rapids (17,493), Tomah (8,769), Mauston (4,264), Black River Falls (3,457), and Nekoosa (2,501). Several cities are actually outside of the geographic boundaries of the ecological landscape but are part of Central Sand Plains counties, and so their influence is included in the analysis that follows. These cities include Marshfield (population 18,848) in northern Wood County and Sparta (8,971) in western Monroe County (USCB 2009). Conversely, several cities are situated just outside Central Sand Plains Ecological Landscape or Central Sand Plains counties boundaries and are not included in the following analysis; notable among them are Wisconsin Dells in Columbia and Sauk counties and Reedsburg and Baraboo in Sauk County.

Population Density

The mean population density of the Central Sand Plains counties (48 persons per square mile) is less than half that of the state as a whole (105 persons per square mile) (USCB 2012b). Population densities in more populous Wood (94.2 persons per square mile) and Portage (87.4 persons per square mile) counties is much higher than in the rest of Central Sand Plains counties. Jackson County (20.7 persons per square mile) has the lowest population density among Central Sand Plains counties.

Population Structure

Age. Age distribution of residents in the Central Sand Plains counties is quite similar to that of the state as a whole but is variable among Central Sand Plains counties and has slightly greater proportion of population older than 65 years of age. Generally, more rural Central Sand Plains counties have older populations than their more populated neighbors. Central Sand Plains counties' population of people under 18 years of age (23.6% of total population) closely mirrors that of the state (22.9%) (USCB 2012b). Among Central Sand Plains counties, Adams County has the lowest percentage of its population under 18 (16.2%), contrasted with the highest percentage of population under 18 in Clark County (29.0%). Central Sand Plains counties have 15.8% of their population aged greater than 65 years of age, moderately greater than the statewide average (13.7%). Individual Central Sand Plains counties are similarly varied in their percentage of people 65 and older; Adams County population is among the oldest in the state (23.7% of its population is 65 or older), while only 12.9% of residents in Portage County are 65 or older.

Minorities. The area is racially homogeneous (as defined by U.S. census reports) with only a 5.9% minority population compared to 13.8% statewide (USCB 2012b). Only 1.0% of Central Sand Plains counties' population is black or African American, and 2.9% is Hispanic, compared to 6.3% and 5.9%, respectively, statewide. Jackson County has a notable American Indian population (6.2% of total population), compared to 1.0% of the statewide population.

The Ho-Chunk tribal offices are located along Highway 54 east of Black River Falls, as is Majestic Pines Casino. Quite a few tribal members live, own land, and work nearby. The tribe hosts a number of cultural events each year near Black River Falls and is an important Wisconsin DNR partner, especially on and around the Black River State Forest.

Education. Educational attainment in the Central Sand Plains counties is less than the statewide average. In terms of percentage of residents 25 years old or older who have graduated from high school, only Portage County (90.4%) exceeds the statewide average (89.4%), followed closely by Wood County (89.2%) (USCB 2012b). The remaining Central Sand Plains counties are among the lowest for high school graduation rates statewide. Clark (80.7%) and Adams (84.0%) counties have the lowest high school graduation rates in the state. Attainment of higher education in Central Sand Plains counties is 17.9% of residents 25 or older who have graduated from college or had higher degrees, compared to 25.8% statewide. Only Portage County (27.1%) exceeds the statewide average for attainment of bachelor's or higher degrees. All other Central Sand Plains counties are below statewide higher education attainment, ranging from Wood County (19.2%) to the two lowest-ranking counties statewide in Juneau and Adams counties (10.8%).

Population Trends

Over the extended period from 1950 to 2006, Central Sand Plains counties' combined population has grown at a slower rate (48% population growth) than has the state's population (62%) (USCB 2009). Though relatively sparsely populated, Adams County has more than doubled its population over the last half century. More populated Wood and Portage counties grew at or above the statewide pace but slowed in recent decades as manufacturing jobs slowed. Population growth patterns in Adams and Juneau counties had the opposite pattern, growing faster in recent decades. In the northwestern corner of the Central Sand Plains Ecological Landscape, Clark County is heavily dependent on a stressed agricultural sector and experienced virtually no population growth (3.4%) from 1950 to 2006.

Much of the Central Sand Plains counties' combined population growth occurred in the decade from 1970 to 1980, when Adams County alone grew 46%, each Central Sand Plains County grew at a faster rate than the state (6.5%), and Central Sand Plains counties combined grew at a 14.5% clip (USCB 2009). From 1980 to 1990, population growth in Central Sand Plains counties slowed to 3.1%, compared to 4.0% statewide, though Adams County population continued to boom (16.5% growth). From 1990 to 2000, population growth in Central Sand Plains counties (8.6%) more closely followed statewide growth (9.6%), with the greatest growth occurring in Adams (18.9%) and Jackson (15.1%) counties. From 2000 to 2010, population growth in Central Sand Plains counties combined slowed further (4.6%) compared to statewide growth (6.0%), and relatively populous Wood County actually experienced population loss (-1.1%) (USCB 2012b).

Housing

Housing Density. The Central Sand Plains counties' combined housing density in 2010 (23.0 housing units per square mile of land) is less than half the state's housing density (48.5 units per square mile) (USCB 2012a). Similar to population density measures, Central Sand Plains counties' housing density is highest in Wood (43.0 housing units per square mile of land) and Portage (37.5) counties, and lowest in Jackson County (9.8). The remaining Central Sand Plains counties have relatively low housing densities ranging from 27.0 housing units per square mile in Adams County to 12.5 housing units per square mile in Clark County.

Seasonal homes have become increasingly common along the shores of impoundments and streams in central Wisconsin. Photo by Wisconsin DNR staff.

Seasonal Homes. Seasonal and recreational homes comprised 8.8% of housing stock in the Central Sand Plains counties in 2010, slightly higher than the statewide average of 6.3% (USCB 2012a). Prevalence of seasonal homes is highly variable within the Central Sand Plains counties; Adams County has an abundance of seasonal homes (39.1% of all housing), as does Juneau County to a lesser degree (16.9%). This indicates relative prominence of tourism and seasonal residents in these counties. The most populous Central Sand Plains counties, Wood (0.9%), Portage (2.2%), and Monroe (2.6%), have much lower percentages of seasonal housing.

Conversion of seasonal residences to permanent residences may result in a change in community values, result in a change in local government priorities, increase cultural conflict between long-term and new residents, increase the proportion of local residents not dependent upon jobs in the local area, and increase costs to provide public and social services. As a result of a shift in land ownership from residents to seasonal residents, locals increasingly cannot afford to own rural or lakeshore property.

Housing Growth. Housing growth in Central Sand Plains counties generally lagged behind the state in the middle part of the 20th century, then surged ahead of statewide levels from 1970 to 1990, and has since generally mirrored statewide housing growth. From 2000 to 2007, housing growth in Central Sand Plains counties (10.2%) was virtually equal to statewide growth (10.3%) (USCB 2009). The most rapid housing growth occurred between 1970 and 1980 when the number of houses in Central Sand Plains counties grew by 41.3% (compared to 30.3% statewide), and Adams County boasted 95.9% housing growth. Relatively high housing growth continued in Central Sand Plains counties (20.8%) from 1980 to 1990, compared to statewide (14.9%). Among Central Sand Plains counties, only Clark County has consistently lagged behind statewide growth over time. Patterns in other Central Sand Plains counties have generally reflected population growth dynamics, though housing growth in areas with much seasonal housing (e.g., Adams County) has outpaced population growth.

Housing Values. Housing values, according to U.S. census data, are lower throughout the Central Sand Plains counties compared to the statewide median ($166,100), but there is variation within the ecological landscape (USCB 2012b). Portage County has the Central Sand Plains counties' highest median housing value ($140,800) while Clark County homes have the lowest median value ($108,600), fourth lowest statewide.

The Economy

Central Sand Plains counties' economies generally perform below statewide averages when compared using the metrics that follow. The more rural counties are at a disadvantage. Per capita income in the Central Sand Plains counties is lower than the statewide average. Unemployment and poverty rates are only slightly above statewide averages, although child poverty tends to be relatively higher in more rural Central Sand Plains counties. Property values are consistently quite low in Central Sand Plains counties, indicating low property tax burdens on residents who work in highly varied local economies. Agriculture, especially in the eastern portion of the Central Sand Plains Ecological Landscape, remains an important part of the local economy, but most economic growth appears to be occurring in tourism-related and service-oriented sectors. Northern Central Sand Plains counties Wood and Portage have stronger and more diverse economies, while Juneau and Adams counties have growing recreational economies.

Income

Per Capita Income. Total personal income for the seven Central Sand Plains counties in 2006 was $8.27 billion (4.3% of the state total), with the majority of income found in the most populous counties, Wood ($2.52 billion) and Portage ($2.08) (USBEA 2006). In 2006, per capita income in Central Sand Plains counties ($29,022) was lower than the statewide average of $34,405 (Table 10.9), and none of the Central Sand Plains counties exceeded the state's average. Per capita incomes in Central Sand Plains counties such as Clark ($24,376) and Juneau ($23,914) are among the lowest in the state.

Household Income. In 2005, median household income levels in Central Sand Plains counties were generally lower than the statewide average ($47,141) (USCB 2009). Only Portage County ($47,140) approaches the statewide average, while median household income in the rest of the Central Sand Plains counties ranges from Wood County's $44,651 to Adams County's $37,434, according to U.S. Census Bureau estimates.

Earnings per Job. Similar to household income, 2006 earnings per job in the seven Central Sand Plains counties ($32,728) are

Table 10.9. *Economic indicators for the Central Sand Plains counties and Wisconsin.*

	Per capita income[a]	Average earnings per job[a]	Unemployment rate[b]	Poverty rate[c]
Wisconsin	**$34,405**	**$36,142**	**4.7%**	**10.2%**
Adams	$25,678	$28,453	6.7%	12.4%
Clark	$24,376	$26,759	5.4%	12.0%
Jackson	$27,623	$30,448	5.5%	10.1%
Juneau	$23,914	$28,012	5.8%	12.8%
Monroe	$26,883	$29,805	4.3%	11.0%
Portage	$30,702	$31,575	4.5%	11.3%
Wood	$33,950	$38,242	5.3%	8.5%
Central Sand Plains counties	**$29,022**	**$32,728**	**5.1%**	**10.3%**

[a]**Source:** U.S. Bureau of Economic Analysis, 2006 figures.
[b]**Source:** U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics, 2006 figures.
[c]**Source:** U.S. Bureau of the Census, Small Area Income and Poverty Estimates, 2005 figures.

lower than the state average ($36,142) (USBEA 2006). Only Wood County ($38,242) had wages per job figures exceeding the state average, while the remaining Central Sand Plains counties ranged from Clark ($26,759) to Portage ($31,575).

Unemployment

The Central Sand Plains counties combined had a 2006 unemployment rate of 5.1%, slightly higher than the statewide average (4.7%) (Table 10.9). Monroe (4.3%) and Portage (4.5%) counties compare favorably to statewide unemployment rates. The remaining counties in the Central Sand Plains Ecological Landscape had considerably higher unemployment rates, ranging from 5.3% in Wood County to 6.7% in Adams County. Since 2008, unemployment rates have become much higher throughout the state.

Poverty

Poverty Rates. The U.S. Census Bureau estimates the Central Sand Plains counties' combined 2005 poverty rate for all people (10.3%) was nearly equal to the state as a whole (10.2%) (USCB 2009). Wood County, with the largest population of any Central Sand Plains counties, also has the lowest poverty rate (8.5%), while the remaining Central Sand Plains counties have poverty rates ranging from 10.1% in Jackson County to 12.8% in Juneau County.

Child Poverty Rates. Child poverty appears to be a greater concern for Central Sand Plains counties than does poverty for all residents. Compared to the statewide average (14%), only Portage (10.6%) and Wood (10.9%) have relatively low 2005 estimates of poverty rates for people under age 18 (USCB 2009). Jackson County (14.7%) had child poverty only slightly higher than the state average, but the remaining four Central Sand Plains counties far exceeded the statewide average. Adams County (21.1%) ranked fourth highest among Wisconsin counties in child poverty rate, and Juneau County (19.8%) ranked seventh highest statewide.

The disparity between child poverty and poverty for all residents in the Central Sand Plains counties appears to be due to the prevalence of an aging population in the Central Sand Plains, especially in Juneau, Adams, and Clark counties. Poverty rates are based on the size of family and tax status (under or over age 65). Poverty thresholds are not adjusted for regional, state, or local variations in the cost of living. So the reason for the difference cannot be variation in local cost of living. As an example, a married couple with two children under 18 has a poverty threshold of $19,157, a married couple under 65 with no children under 18 has a threshold of $12,649, and a married couple over 65 with no children under 18 has a threshold of $11,418 (USCB 2009). Significantly more people are over age 65 in Central Sand Plains counties (14.6% compared with 13% statewide). Even with a lower per capita income, the older population would be expected to have a lower percentage of people under their lower poverty level since social security alone would usually put them above the minimum threshold.

Residential Property Values

Overall, residential property values in the Central Sand Plains counties ($88,828 per housing unit) are much lower than the statewide average ($134,021 per housing unit) (Table 10.10). Among the 16 ecological landscapes, only the Southwest Savanna counties ($86,167) have lower overall residential property values than the Central Sand Plains counties. Central Sand Plains counties' residential property values are highly variable among counties. The Central Sand Plains counties low average residential property values range from the state's fourth lowest average value of $64,683 in Clark County to the highest of $118,136 in Adams County. The Central Sand Plains counties' lowest residential values occur in its three westernmost counties, Clark, Jackson, and Monroe counties.

Important Economic Sectors

Central Sand Plains counties together provided 169,076 jobs in 2007 (Table 10.11), or about 4.8% of the total employment in Wisconsin. Wood County (with 52,662 jobs in 2007) and Portage County (43,240) are the major contributors of

employment in the Central Sand Plains counties (MIG 2009). The remaining counties provide relatively few jobs, ranging from 24,766 jobs in Monroe County to 8,762 jobs in Adams County. Health Care and Social Services (13.5% of employment in Central Sand Plains counties) and Government (13.4%) are the largest sectors in terms of both employment and employee compensation. For definitions of economic sectors, see the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

Economic sectors of secondary importance in Central Sand Plains counties include Manufacturing (non-wood) (8.7%), Tourism-related (10.8% of employment), Retail Trade (8.9%), and Agriculture, Fishing, and Hunting (7.5%). Forest Products and Processing comprises only 4.5% of employment in Central Sand Plains counties but is the second-leading economic sector in terms of industry output ($3 billion in value in 2007) in Central Sand Plains counties.

Importance of economic sectors within the Central Sand Plains counties when compared to the rest of the state was evaluated using an economic base analysis to yield a standard metric called a location quotient (Quintero 2007). Economic base analysis compares the percentage of all jobs in

Table 10.10. *Property values for the Central Sand Plains counties and Wisconsin, assessed in 2006 and collected in 2007.*

	Residential property value	Housing units	Residential property value per housing unit
Wisconsin	**$340,217,559,700**	**2,538,538**	**$134,021**
Adams	$1,902,109,400	16,101	$118,136
Clark	$935,127,800	14,457	$64,683
Jackson	$647,692,400	8,883	$72,914
Juneau	$1,321,396,100	13,989	$94,460
Monroe	$1,373,182,800	18,703	$73,420
Portage	$2,934,090,500	28,887	$101,571
Wood	$2,821,655,800	33,343	$84,625
Central Sand Plains counties	**$11,935,254,800**	**134,363**	**$88,828**

Sources (except housing units): Wisconsin Department of Revenue 2006–2007 property tax master file. Housing Units: U. S. Census Bureau estimates for July 1, 2006.

Table 10.11. *Total and percentage of jobs in 2007 in each economic sector within the Central Sand Plains (CSP) counties. The economic sectors providing the highest percentage of jobs in the CSP counties are highlighted in blue.*

Industry sector	WI employment	% of WI total	CSP counties employment	% of CSP counties total
Agriculture, Fishing & Hunting	110,408	3.1%	12,651	7.5%
Forest Products & Processing	88,089	2.5%	7,663	4.5%
Mining	3,780	0.1%	142	0.1%
Utilities	11,182	0.3%	433	0.3%
Construction	200,794	5.6%	8,529	5.0%
Manufacturing (non-wood)	417,139	11.7%	14,633	8.7%
Wholesale Trade	131,751	3.7%	3,819	2.3%
Retail Trade	320,954	9.0%	15,048	8.9%
Tourism-related	399,054	11.2%	18,327	10.8%
Transportation & Warehousing	108,919	3.1%	11,011	6.5%
Information	57,081	1.6%	1,871	1.1%
Finance & Insurance	168,412	4.7%	7,138	4.2%
Real Estate, Rental & Leasing	106,215	3.0%	2,987	1.8%
Professional, Science & Tech Services	166,353	4.7%	3,603	2.1%
Management	43,009	1.2%	1,285	0.8%
Administrative and Support Services	166,405	4.7%	3,423	2.0%
Private Education	57,373	1.6%	1,066	0.6%
Health Care & Social Services	379,538	10.7%	22,884	13.5%
Other Services	187,939	5.3%	9,876	5.8%
Government	430,767	12.1%	22,688	13.4%
Totals	**3,555,161**		**169,076**	**4.8%**

Source: IMPLAN, © MIG, Inc. (MIG 2009).

an ecological landscape county approximation for a given economic sector to the percentage of all jobs in the state for the same economic sector. For example, if 10% of the jobs within a county approximation are in the manufacturing sector and 10% of all jobs in the state are in the manufacturing sector, the location quotient would be 1.0, indicating that this county approximation contributes jobs to the manufacturing sector at the same rate as the statewide average. If the location quotient is greater than 1.0, the county approximation is contributing more jobs to the sector than the state average. If the location quotient is less than 1.0, the county approximation is contributing fewer jobs to the sector than the state average.

When compared with the rest of the state, the Central Sand Plains counties had six sectors with location quotients higher than 1.0, indicating their relative importance within the county approximation (Figure 10.17). Sectors providing a percentage of jobs higher than the state average, listed in order of their relative importance, are Agriculture, Fishing and Hunting; Transportation and Warehousing (third-highest quotient among county approximations); Forest Products and Processing; Health Care and Social Services; Government; and Other Services (see Appendix 10.I, "Importance of Economic Sectors within the Central Sand Plains Counties Compared to the Rest of the State," at the end of this chapter).

The Other Services sector consists primarily of equipment and machinery repairing, promoting or administering religious activities, providing dry-cleaning and laundry services, personal care services, death care services, pet care services, and photo finishing services. The Tourism-related sector includes relevant subsectors within Retail Trade; Passenger Transportation; Arts, Entertainment, and Recreation; and Accommodation and Food Services. The Forest Products and Processing sector includes sectors in Logging, Pulp and Paper Manufacturing, Primary Wood Manufacturing (e.g., sawmills), and Secondary Wood Manufacturing (e.g., furniture manufacturing). Pulp and Paper Manufacturing is a very important segment of the forest products and processing industries in the Central Sand Plains counties.

Urban Influence

The U.S. Department of Agriculture's Economic Research Service (USDA ERS) divides counties into 12 groups on a continuum of urban influence, with 1 representing large metropolitan areas, 2 representing smaller metropolitan areas, and the remaining classes from 3 to 12 representing nonmetropolitan counties increasingly less populated and isolated from urban influence (USDA ERS 2012b). The concept of urban influence assumes that population size, urbanization, and access to larger adjacent economies are crucial elements in evaluating potential of local economies. All Central Sand Plains counties are nonmetropolitan (rural) in character. The class 5 counties (micropolitan area adjacent to small metropolitan area), Wood and Portage, experience the greatest degree of urban influence among Central Sand Plains counties, followed by Clark, Jackson, and Monroe counties (class 6). Adams County is classified as a class 7 county, while Juneau County enjoys the least urban influence among Central Sand Plains counties (class 9).

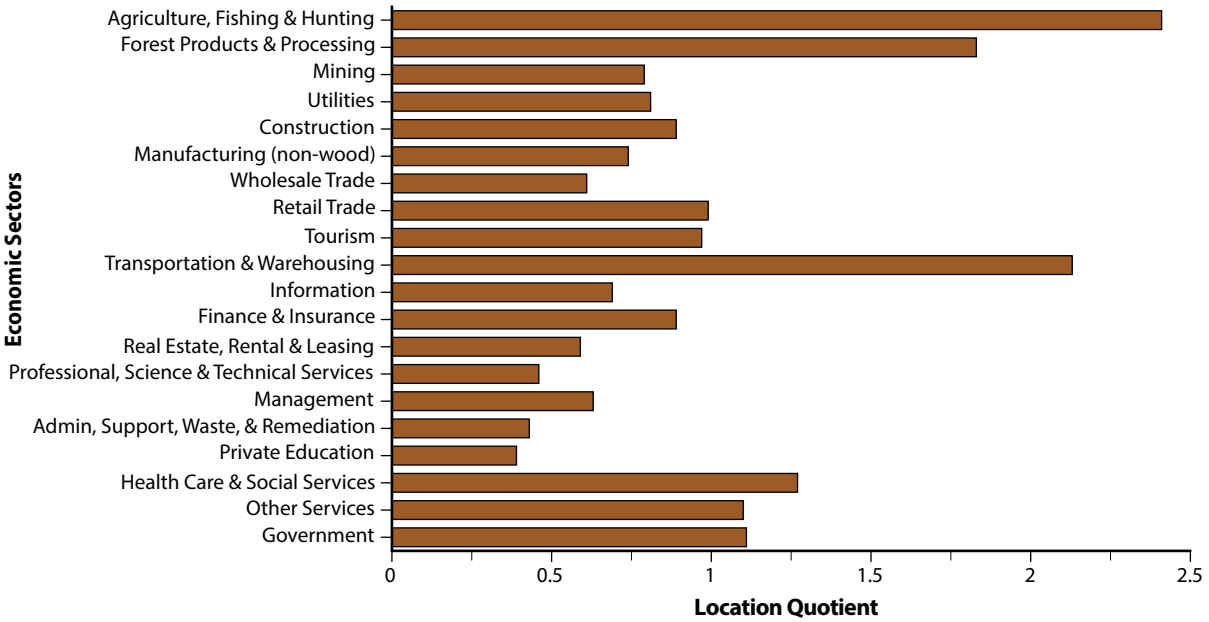


Figure 10.17. *Importance of economic sectors within the Central Sand Plains counties when compared to the rest of the state. If the location quotient is greater than 1.0, the Central Sand Plains is contributing more jobs to that economic sector than the state average. If the location quotient is less than 1.0, the Central Sand Plains is contributing fewer jobs to that economic sector than the state average.*

Economic Types

The USDA ERS classifies counties in one of six mutually exclusive categories: farming-dependent counties, mining-dependent counties, manufacturing-dependent counties, government-dependent counties, service-dependent counties, and nonspecialized counties (USDA ERS 2012a). Central Sand Plains counties are diverse in their economic typology. Juneau and Wood counties were classified as manufacturing-dependent in 2004, according to Economic Research Service economic specialization definitions. Adams and Monroe counties were classified as government-dependent, Clark County is farming-dependent. Jackson and Portage counties were classified as nonspecialized.

Policy Types

The USDA ERS classifies counties according to "policy types" deemed especially relevant to rural development policy (USDA ERS 2012a). Only Juneau County is cited as a "nonmetro recreation" county. Nonmetro recreation counties are rural counties classified using a combination of factors, including share of employment or share of earnings in recreation-related industries in 1999, share of seasonal or occasional use housing units in 2000, and per capita receipts from motels and hotels in 1997, indicating economic dependence especially upon an influx of tourism and recreational dollars. Adams County was classified as both a "nonmetro recreation" county and "retirement destination" county. Retirement destination counties (in which the number of residents 60 and older grew by 15% or more between 1990 and 2000 due to ***in-migration***) are shaped by an influx of an older population and have particular needs for health care and services specific to that population.

Integrated Opportunities for Management

Use of natural resources for human needs within the constraints of sustainable ecosystems is an integral part of ecosystem management. Integrating ecological management with socioeconomic programs or activities can result in efficiencies in land use, tax revenues, and private capital. This type of integration can also help generate broader and deeper support for sustainable ecosystem management. However, any human modification or use of natural communities has trade-offs that benefit some species and harm others. Even relatively benign activities such as ecotourism will have impacts on the ecology of an area. Trade-offs caused by management actions need to be carefully weighed when planning management to ensure that some species are not being irreparably harmed. Maintaining healthy, sustainable ecosystems provides many benefits to people and our economy. The development of ecologically sound management plans should save money and sustain natural resources in the long run.

Principles of integrating natural resources and socioeconomic activities are similar across the state. See "Integrated Ecological and Socioeconomic Opportunities" in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in Part 1 of the book. That section offers suggestions on how and when ecological and socioeconomic needs might be integrated and gives examples of the type of activities that might work together when planning the management of natural resources within a given area.

Appendices

Appendix 10.A. *Watershed water quality summary for the Central Sand Plains Ecological Landscape.*

Watershed no.	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Poor/Fair/Good/Very Good/Excellent)
BR04	Trout Run & Robinson creeks	138,833	Fair to V Good; cranberry marshes; channel modification; NPS; Hab; Flux; some ERW streams; borderline eutrophic impoundments
BR05	Morrison Creek	114,008	Fair to V Good; cranberry marshes; channel modification; NPS; Hab; Flux; borderline eutrophic impoundments
BR06	Halls Creek	73,685	Good to V Good; Several ERW: channel modification; Hab; some lakes eutrophic from NPS
BR07	East Fork Black River	195,798	Fair to Good; cranberry marshes; temp; two lakes eutrophic from NPS
BR08	Five Mile & Wedges creeks	91,632	Fair to Good; streambank pasturing; beaver dams; Hab; Sed; thermal impacts; Lake Arbutus 303(d) (Hg)
BR09	O'Neill & Cunningham creeks	103,582	Fair to Good; streambank pasturing; erosion; Hab; Sed; Flux
CW01	Little Roche A Cri Creek	125,567	Good to V Good; wind erosion, ditching, cranberries & irrigation > pesticides & NPS in streams
CW02	Lower Yellow River	167,075	Fair to V Good; widespread ditching; expansive wetlands; cranberry/Agr NPS; all lakes NPS impacted
CW03	Cranberry Creek	81,601	Fair; cranberry NPS impacts; erosion; pesticides; shallow lakes w/ low D.O.
CW04	Hemlock Creek	61,690	Fair; water & wind soil erosion; Sed; NPS; low D.O.; groundwater radon
CW05	Upper Yellow River	136,291	Poor to Fair; heavy water & wind erosion; high Agr NPS; Flux; impoundments eutrophic; Hab
CW06	Big Roche A Cri Creek	113,279	Poor to V Good; Agr NPS; ditching; water & wind erosion; Sed; impoundments; eutrophic lakes
CW07	Fourteen Mile Creek	117,856	Fair; Agr ditching; Sed; cranberry/NPS nitrates; wind erosion; impoundments eutrophic/algae/weeds; mussel toxicity; high groundwater nitrates & iron
CW08	Wisconsin Rapids	85,707	Poor to V Good; Hab; Sed; urban NPS; wind erosion
CW09	Sevenmile & Tenmile creeks	71,834	Fair to Good; ditching; grazing, erosion; flux; temp; cranberry/NPS nitrates & pesticides; Hab; hi-cap wells
CW10	Fourmile & Fivemile creeks	136,933	Poor to Excellent; ditching; erosion; Sed; Hab; NPS nutrients; low D.O.; pesticides; streambank grazing; hi-cap well > dry trout stream; impoundment weeds
CW11	Mill Creek	106,786	Poor to Good; streambank grazing; Sed; Hab; high runoff > bank erosion; impoundments; GW coliform
CW12	Plover & Little Plover rivers	129,402	Fair to Excellent; NPS pesticides/nutrients; Hab; Temp; Sed; hi-cap well drawdown impacts on Little Plover River > minimum flow order March 2009; lakes/ponds meso- to eutrophic
CW13	Little Eau Claire River	81,261	Fair; Sed; Hab; Flux; high GW nitrate & pesticide
LC14	Lower Eau Claire River[b]	138,438	Fair to V Good; dams/streambank grazing > Hab/Sed; impoundments eutrophic: weeds/algae
LC15	Black & Hay creeks	102,328	Fair to Good; dams > Sed; Temp; Hab; eutrophic Impoundments
LC16	South Fork, Eau Claire River	146,871	Good; beaver dams/streambank grazing > Hab/Sed Temp; impoundments: eutrophic; Hg
LC17	North Fork, Eau Claire River	131,767	Good to V Good; streambank grazing > Hab; low D.O.; impoundment NPS > weeds/algae

Appendix 10.A, *continued.*

Watershed no.	Watershed name	Area (acres)[a]	Overall water quality and major stressor[b] (Range = Poor/Fair/Good/Very Good/Excellent)
LW22	Narrows Cr. & Baraboo River	112,850	Fair to Good; 31% forest: 49% Agr; barnyard & land-spread NPS; ditching; Hab; GW pesticide/nitrate; impoundments eutrophic
LW25	Duck & Plainville creeks	124,858	Fair to V Good; 51% forest, 26% Agr; NPS; ditching/dams > Temp/Flux; GW pesticide/nitrate
LW26	Dell Creek	85,588	Poor to V Good; 45% forest, 34% Agr; urban & rural NPS; dams/ditching > Temp/Sed/Hab; GW pesticide/nitrate; impoundments eutrophic
LW27	Lower Lemonweir River	134,159	Fair to V Good; 40% forest, 34% Agr; cranberries; streambank grazing > erosion/Hab/Sed; Agr/urban NPS; GW pesticide/nitrate; impoundment eutrophic
LW28	Beaver Creek (Juneau Co.)	180,973	Fair to V Good; 42% wetland, 36% forest; cranberry ditching/impoundments > Temp/low D.O./Hab
LW29	Little Lemonweir River	139,524	Good to V Good; 31% forest, 38% Agr; barnyard NPS; stream bank grazing > erosion/Temp; ditching; coliform; Lake Tomah eutrophic; GW pesticides; springs
WR07	Upper Little Wolf River	116,512	Good to Excellent; streambank grazing > manure NPS/Hab/erosion/Temp; GW pesticide; mesotrophic lakes

Source: Wisconsin DNR Bureau of Watershed data.

[a]Based on Wisconsin DNR watershed water quality reports.

[b]Only a small fraction of this watershed lies within this ecological landscape, so overall impacts of land uses within the landscape are unlikely to impact water quality within the watershed to any appreciable degree.

Abbreviations:
Agr = Agricultural.
D.O. = Dissolved Oxygen levels are low.
d.s. = Downstream of this ecological landscape.
ERW = Exceptional Resource Water (very good to excellent water quality, with point source discharges).
Flux = Abnormal highs and lows in stream flow fluctuation due to lack of groundwater infiltration, etc., often due to loss of forest cover or creation of excessive impermeable surface.
GW = Groundwater (without modifiers, indicates high nitrates, radon, manganese, or other negative use condition).
Hab = stream habitat damage.
Hg = Mercury contamination of fish, mainly deposited by coal combustion, or sometimes by industry.
Mod = Modification of stream channel, habitat structure, or other aquatic feature.
Muni = Municipal.
NPS = Nonpoint source pollutants, such as farm or parking lot runoff, or septic system leakage.
ORW = Outstanding Resource Water (very good to excellent water quality, with no point source discharges).
P = Phosphorous in excessive amounts, reducing oxygen concentration in a water body.
PAH = Polycyclic aromatic hydrocarbon contamination, often with other toxic substances.
PCBs = Polychlorinated biphenyl industrial pollutants in sediment and aquatic life.
PS = Point source pollutants, such as treated municipal and industrial wastewater.
Sed = Excess sedimentation.
Temp = Elevated temperatures in some stream reaches.
TSI = Trophic state index (indication of impacts of excess nutrients).
Tribs = Streams that are tributary to the stream(s) after which the watershed is named.
u.s. = Upstream of this ecological landscape.
303d = A water listed as impaired under Section 303(d) of the federal Clean Water Act.
> = Yields, creates, or results in (the listed impacts).

Appendix 10.B. *Forest habitat types in the Central Sand Plains Ecological Landscape.*

The forest habitat type classification system (FHTCS) is a site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. This classification system enables the recognition and classification of ecologically similar landscape units (site types) and forest plant communities (vegetation associations).

A forest habitat type is an aggregation of sites (units of land) capable of producing similar late-successional (potential climax) forest plant communities. Each recognizable habitat type represents a relatively narrow segment of environmental variation that is characterized by a certain limited potential for vegetation development. Although at any given time, a habitat type can support a variety of disturbance-induced (seral) plant communities, the ultimate product of succession is presumed to be a similar climax community. Field identification of a habitat type provides a convenient label (habitat type name) for a given site and places that site in the context of a larger group of sites that share similar ecological traits. Forest habitat type groups more broadly combine individual habitat types that have similar ecological potentials.

Individual forest cover types classify current overstory vegetation, but these associations usually encompass a wide range of environmental conditions. In contrast, individual habitat types group ecologically similar sites in terms of vegetation potentials. Management interpretations can be refined and made significantly more accurate by evaluating a stand in terms of the current cover type (current dominant vegetation) plus the habitat type (potential vegetation).

Habitat Types	Description of forest habitat types found in the Central Sand Plains Ecological Landscape.
ArDe	*Acer rubrum/Desmodium* Red maple/pointed-leaf tick trefoil
PEu	*Pinus strobus/Euphorbia corollata* White pine/flowering spurge
PVCr	*Pinus strobus/Vaccinium-Cornus racemosa* White pine/blueberry-gray dogwood
PVG	*Pinus strobus/Vaccinium-Gaultheria* White pine/blueberry-huckleberry
PVGy	*Pinus strobus/Vaccinium-Gaylussacia* White pine/blueberry-huckleberry
PVHa	*Pinus strobus/Vaccinium-Hamamelis* White pine/blueberry-witch hazel
PVRh	*Pinus strobus/Vaccinium-Rubus hispidus* White pine/blueberry-dewberry

Appendix 10.C. *The Natural Heritage Inventory (NHI) table of rare species and natural community occurrences (plus a few miscellaneous features tracked by the NHI program) for the Central Sand Plains (CSP) Ecological Landscape in November 2009. See the Wisconsin Natural Heritage Working List online for the most current status (Wisconsin DNR 2009).*

Scientific name (common name)	Lastobs Date	EOs[a] in CSP	EOs in WI	Percent in CSP	State rank	Global rank	State status	Federal status
MAMMALS								
Canis lupus (gray wolf)	2008	26	204	13%	S2	G4	SC/FL	LE
Microtus ochrogaster (prairie vole)	1974	8	19	42%	S1S2	G5	SC/N	
Sorex arcticus (arctic shrew)	1998	8	31	26%	S3S4	G5	SC/N	
Sorex hoyi (pygmy shrew)	1998	8	39	21%	S3S4	G5	SC/N	
Sorex palustris (water shrew)	1997	3	13	23%	S2S3	G5	SC/N	
Spermophilus franklinii (Franklin's ground squirrel)	1977	2	12	17%	S2	G5	SC/N	
BIRDS[b]								
Accipiter gentilis (Northern Goshawk)	1999	6	141	4%	S2B,S2N	G5	SC/M	
Ammodramus henslowii (Henslow's Sparrow)	2006	6	82	7%	S3B	G4	THR	
Ammodramus leconteii (Le Conte's Sparrow)	2006	7	22	32%	S2S3B	G4	SC/M	
Ardea alba (Great Egret)	1986	1	14	7%	S2B	G5	THR	
Bartramia longicauda (Upland Sandpiper)	2002	1	54	2%	S2B	G5	SC/M	
Botaurus lentiginosus (American Bittern)	2005	7	41	17%	S3B	G4	SC/M	
Buteo lineatus (Red-shouldered Hawk)	2007	40	301	13%	S3S4B,S1N	G5	THR	
Chlidonias niger (Black Tern)	1999	10	60	17%	S2B	G4	SC/M	
Coccyzus americanus (Yellow-billed Cuckoo)	2007	1	39	3%	S3B	G5	SC/M	
Cygnus buccinator (Trumpeter Swan)	1999	9	22	41%	S4B	G4	SC/M	
Dendroica cerulea (Cerulean Warbler)[c]	2001	8	92	9%	S2S3B	G4	THR	
Dendroica kirtlandii (Kirtland's Warbler)[c]	2009	7	11	64%	S1	G1	SC/FL	LE
Empidonax virescens (Acadian Flycatcher)	2001	2	47	4%	S3B	G5	THR	
Haliaeetus leucocephalus (Bald Eagle)	2008	52	1286	4%	S4B,S2N	G5	SC/P	
Ixobrychus exilis (Least Bittern)	1999	4	23	17%	S3B	G5	SC/M	
Lanius ludovicianus (Loggerhead Shrike)	2001	2	31	6%	S1B	G4	END	
Nyctanassa violacea (Yellow-crowned Night-heron)	1984	1	7	14%	S1B	G5	THR	
Oporornis agilis (Connecticut Warbler)	1999	2	27	7%	S2S3B	G4	SC/M	
Oporornis formosus (Kentucky Warbler)[c]	1997	1	31	3%	S1S2B	G5	THR	
Pandion haliaetus (Osprey)	2007	48	733	7%	S4B	G5	SC/M	
Podiceps grisegena (Red-necked Grebe)	1999	1	13	8%	S1B	G5	END	
Protonotaria citrea (Prothonotary Warbler)	2001	4	40	10%	S3B	G5	SC/M	
Rallus elegans (King Rail)	1985	1	6	17%	S1B	G4	SC/M	
Seiurus motacilla (Louisiana Waterthrush)[c]	2001	9	34	26%	S3B	G5	SC/M	
Sterna forsteri (Forster's Tern)	1986	1	31	3%	S1B	G5	END	
Tympanuchus cupido (Greater Prairie-chicken)	2005	40	60	67%	S1B,S2N	G4	THR	
Tympanuchus phasianellus (Sharp-tailed Grouse)	2003	3	7	43%	S1B,S2N	G4	SC/H	
Tyto alba (Barn Owl)	1979	3	29	10%	S1B,S1N	G5	END	
Vireo bellii (Bell's Vireo)	1987	1	43	2%	S2B	G5	THR	
HERPTILES								
Acris crepitans (northern cricket frog)	1984	6	102	6%	S1	G5	END	
Apalone mutica (smooth softshell)	2006	2	5	40%	S3	G5	SC/H	
Coluber constrictor (North American racer)	2000	1	14	7%	S2	G5	SC/P	
Diadophis punctatus edwardsii (Northern ring-necked snake)	1999	2	23	9%	S3?	G5T5	SC/H	
Emydoidea blandingii (Blanding's turtle)	2008	33	316	10%	S3	G4	THR	
Glyptemys insculpta (wood turtle)	2007	18	262	7%	S2	G4	THR	
Hemidactylium scutatum (four-toed salamander)	1998	5	63	8%	S3	G5	SC/H	

Continued on next page

Appendix 10.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSP	EOs in WI	Percent in CSP	State rank	Global rank	State status	Federal status
Lithobates catesbeianus (American bullfrog)	1998	3	70	4%	S3	G5	SC/H	
Ophisaurus attenuatus (slender glass lizard)	2006	15	67	22%	S1	G5	END	
Sistrurus catenatus catenatus (eastern massasauga)	2005	4	13	31%	S1	G3G4T3T4Q	END	C
Terrapene ornata (ornate box turtle)	1986	1	29	3%	S1	G5	END	
FISHES								
Anguilla rostrata (American eel)	1975	1	24	4%	S2	G4	SC/N	
Aphredoderus sayanus (pirate perch)	1995	6	39	15%	S3	G5	SC/N	
Clinostomus elongatus (redside dace)	1994	7	96	7%	S3	G3G4	SC/N	
Cycleptus elongatus (blue sucker)	2008	1	8	13%	S2	G3G4	THR	
Etheostoma clarum (western sand darter)	1994	3	11	27%	S3	G3	SC/N	
Lythrurus umbratilis (redfin shiner)	2004	3	37	8%	S2	G5	THR	
Macrhybopsis aestivalis (shoal chub)	1994	1	10	10%	S2	G5	THR	
Macrhybopsis storeriana (silver chub)	1993	1	13	8%	S3	G5	SC/N	
Moxostoma carinatum (river redhorse)	1978	1	43	2%	S2	G4	THR	
Notropis texanus (weed shiner)	1973	1	45	2%	S3	G5	SC/N	
Percina evides (gilt darter)	1979	1	26	4%	S2	G4	THR	
MUSSELS/CLAMS								
Alasmidonta marginata (elktoe)	1997	5	44	11%	S4	G4	SC/P	
Cyclonaias tuberculata (purple wartyback)	1997	1	16	6%	S1S2	G5	END	
Plethobasus cyphyus (bullhead/sheepnose)	2009	1	5	20%	S1	G3	END	C
Pleurobema sintoxia (round pigtoe)	1993	2	50	4%	S3	G4G5	SC/P	
Simpsonaias ambigua (salamander mussel)	1992	7	51	14%	S2S3	G3	THR	
Tritogonia verrucosa (buckhorn)	1997	2	12	17%	S2	G4G5	THR	
BUTTERFLIES/MOTHS								
Atrytonopsis hianna (dusted skipper)	2002	20	31	65%	S3	G4G5	SC/N	
Callophrys gryneus (juniper hairstreak)	1987	1	8	13%	S3	G5	SC/N	
Callophrys henrici (henry's elfin)	2003	5	19	26%	S1S2	G5	SC/N	
Callophrys irus (frosted elfin)	2006	17	17	100%	S1	G3	THR	
Chlosyne gorgone (gorgone checker spot)	2006	12	40	30%	S3	G5	SC/N	
Erynnis martialis (mottled dusky wing)	1995	3	10	30%	S2	G3	SC/N	
Erynnis persius (persius dusky wing)	2003	21	26	81%	S2	G5	SC/N	
Euphyes bimacula (two-spotted skipper)	1998	6	17	35%	S3	G4	SC/N	
Grammia phyllira (phyllira tiger moth)	1993	1	14	7%	S2	G4	SC/N	
Hemileuca sp. 3 (midwestern fen buckmoth)	2002	4	10	40%	S3	G5T3T4	SC/N	
Hesperia leonardus (Leonard's skipper)	2002	7	29	24%	S3	G4	SC/N	
Hesperia metea (cobweb skipper)	1996	6	12	50%	S2	G4G5	SC/N	
Lycaeides melissa samuelis (Karner blue)	2006	189	316	60%	S3	G5T2	SC/FL	LE
Lycaena dione (gray copper)	2002	4	14	29%	S2	G5	SC/N	
Papaipema beeriana (liatris borer moth)	1997	1	11	9%	S2	G2G3	SC/N	
Phyciodes batesii lakota (Lakota crescent)	1992	1	24	4%	S3	G4T4	SC/N	
Poanes massasoit (mulberry wing)	1988	1	56	2%	S3	G4	SC/N	
Schinia indiana (phlox moth)	2002	11	31	35%	S2S3	G2G4	END	
Speyeria idalia (regal fritillary)	2008	4	24	17%	S1	G3	END	
DRAGONFLIES/DAMSELFLIES								
Chromagrion conditum (aurora damselfly)	1998	7	17	41%	S3	G5	SC/N	
Libellula cyanea (white-spangled skimmer)	1981	1	2	50%	S1	G5	SC/N	
Neurocordulia molesta (smoky shadowfly)	1997	3	9	33%	S2S3	G4	SC/N	

Appendix 10.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSP	EOs in WI	Percent in CSP	State rank	Global rank	State status	Federal status
Ophiogomphus smithi (sand snaketail)	2002	12	28	43%	S2	G2G3	SC/N	
Somatochlora incurvata (warpaint emerald)	2004	16	18	89%	S2	G4	END	
Somatochlora tenebrosa (clamp-tipped emerald)	1997	4	6	67%	S1S2	G5	SC/N	
Stylurus plagiatus (russet-tipped clubtail)	1995	2	8	25%	S2	G5	SC/N	
Sympetrum danae (black meadowhawk)	1997	1	6	17%	S3	G5	SC/N	
Williamsonia lintneri (ringed boghaunter)	2004	15	15	100%	S2	G3	SC/N	
BEETLES								
Agabus bicolor (a predaceous diving beetle)	2004	5	9	56%	S3	GNR	SC/N	
Cicindela lepida (little white tiger beetle)	1998	5	13	38%	S2	G3G4	SC/N	
Cicindela patruela huberi (a tiger beetle)	2004	53	84	63%	S3	G3T3	SC/N	
Cymbiodyta acuminata (a water scavenger beetle)	1997	1	7	14%	S3	GNR	SC/N	
Haliplus pantherinus (a crawling water beetle)	1998	1	13	8%	S2S3	GNR	SC/N	
Hydroporus badiellus (a predaceous diving beetle)	1997	3	7	43%	S3?	GNR	SC/N	
Hydroporus vittatus (a predaceous diving beetle)	1998	5	17	29%	S3	GNR	SC/N	
Ilybius discedens (a predaceous diving beetle)	1997	1	3	33%	S3	GNR	SC/N	
Laccobius reflexipennis (a predaceous diving beetle)	1997	1	3	33%	S1S2	GNR	SC/N	
Liodessus cantralli (Cantrall's bog beetle)	2004	1	4	25%	S1S2	GNR	SC/N	
MISCELLANEOUS INSECTS/SPIDERS								
Arphia conspersa (speckled rangeland grasshopper)	1998	5	8	63%	S2	G5	SC/N	
Banksiola dossuaria (a giant casemaker caddisfly)	2005	2	5	40%	S2S3	G5	SC/N	
Dichromorpha viridis (short-winged grasshopper)	1996	1	4	25%	S3?	G5	SC/N	
Isoperla bilineata (a perlodid stonefly)	1992	2	8	25%	S2S3	G5	SC/N	
Isoperla marlynia (a perlodid stonefly)	1994	1	5	20%	S3	G5	SC/N	
Limotettix pseudosphagneticus (a leafhopper)	1997	1	1	100%	S1?	GNR	SC/N	
Melanoplus fasciatus (huckleberry spur-throat grasshopper)	1997	4	4	100%	S2S3	G5	SC/N	
Melanoplus stonei (stone's Locust)	1997	1	1	100%	S1S2	G4G5	SC/N	
Ochrotrichia riesi (a purse casmaker caddisfly)	1998	1	1	100%	S1?	G3G4	SC/N	
Orphulella pelidna (spotted-winged grasshopper)	2005	4	7	57%	S2S3	G5	SC/N	
Paradamoetas fontana (a jumping spider)	1997	4	4	100%	S1S2	GNR	SC/N	
Polyamia dilata (prairie leafhopper)	1997	1	20	5%	S2	GNR	THR	
Psinidia fenestralis (sand locust)	1998	3	4	75%	S3?	G5	SC/N	
Soyedina vallicularia (a nemourid broad-backed stonefly)	1997	1	1	100%	S1	G5	SC/N	
Trachyrhachys kiowa (ash-brown grasshopper)	1999	3	4	75%	S2	G5	SC/N	
PLANTS								
Agalinis gattingeri (roundstem foxglove)	1997	1	23	4%	S3	G4	THR	
Anemone multifida var. *hudsoniana* (early anemone)	2000	1	1	100%	S1	G5T5	END	
Arethusa bulbosa (swamp-pink)	1998	1	96	1%	S3	G4	SC	
Asclepias ovalifolia (dwarf milkweed)	2000	24	60	40%	S3	G5?	THR	
Asplenium trichomanes (maidenhair spleenwort)	2000	8	27	30%	S3	G5	SC	
Aster longifolius (long-leaved Aster)	1982	2	2	100%	S1	G5	SC	
Bartonia paniculata (twining screwstem)	2005	3	4	75%	S1	G5	SC	
Bartonia virginica (yellow screwstem)	2007	77	81	95%	S3	G5	SC	
Cacalia suaveolens (sweet-scented Indian-plantain)	1981	1	28	4%	S3	G4	SC	
Calamagrostis stricta (slim-stem small-reedgrass)	1985	3	34	9%	S3	G5	SC	
Carex assiniboinensis (assiniboine sedge)	1997	3	33	9%	S3	G4G5	SC	
Carex backii (rocky mountain sedge)	1981	1	4	25%	S1	G4	SC	
Carex cumulata (clustered sedge)	1997	8	8	100%	S2	G4?	SC	

Continued on next page

Appendix 10.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSP	EOs in WI	Percent in CSP	State rank	Global rank	State status	Federal status
Carex folliculata (long sedge)	2007	60	69	87%	S3	G4G5	SC	
Carex livida var. *radicaulis* (livid sedge)	1998	1	21	5%	S2	G5T5	SC	
Carex straminea (straw sedge)	1999	2	2	100%	S1	G5	SC	
Ceratophyllum echinatum (prickly hornwort)	1998	3	61	5%	S2	G4?	SC	
Crotalaria sagittalis (arrow-headed rattle-box)	1973	1	2	50%	S1	G5	SC	
Diarrhena obovata (beak Grass)	2006	1	11	9%	S2	G4G5	END	
Didiplis diandra (water-purslane)	1997	3	4	75%	S1	G5	SC	
Dryopteris fragrans var. *remotiuscula* (fragrant fern)	1995	1	27	4%	S3	G5T3T5	SC	
Eleocharis wolfii (wolf spikerush)	1995	1	2	50%	S1	G3G4	END	
Eleocharis engelmannii (engelmann spike-rush)	1972	1	4	25%	S1	G4G5Q	SC	
Glycyrrhiza lepidota (wild licorice)	1974	2	6	33%	S1S2	G5	SC	
Gnaphalium helleri var. *micradenium* (catfoot)	1998	1	1	100%	S1	G4G5T3?	SC	
Gnaphalium obtusifolium var. *saxicola* (cliff cudweed)	2001	6	10	60%	S2	G5T2	THR	
Houstonia caerulea (innocence)	1975	1	8	13%	S2	G5	SC	
Huperzia porophila (rock clubmoss)	1997	8	22	36%	S3	G4	SC	
Juncus marginatus (grassleaf rush)	1997	9	10	90%	S2	G5	SC	
Lycopodiella margueritae (northern prostrate clubmoss)	2002	1	1	100%	S1	G2	SC	
Myriophyllum farwellii (Farwell's water-milfoil)	1997	12	60	20%	S3	G5	SC	
Opuntia fragilis (brittle prickly-pear)	1997	3	36	8%	S3	G4G5	THR	
Orobanche uniflora (one-flowered broomrape)	1994	1	30	3%	S3	G5	SC	
Oryzopsis canadensis (Canada mountain-ricegrass)	1997	1	4	25%	S1	G5	SC	
Platanthera flava var. *herbiola* (pale green orchid)	1994	3	20	15%	S2	G4T4Q	THR	
Poa paludigena (bog bluegrass)	1997	4	41	10%	S3	G3	THR	
Poa sylvestris (woodland bluegrass)	1988	1	3	33%	S1	G5	SC	
Polygala cruciata (crossleaf milkwort)	2007	80	83	96%	S3	G5	SC	
Polytaenia nuttallii (prairie parsley)	1990	2	26	8%	S3	G5	THR	
Potamogeton confervoides (algae-like pondweed)	1975	1	9	11%	S2	G4	THR	
Potamogeton diversifolius (water-thread pondweed)	2005	11	29	38%	S2	G5	SC	
Potamogeton vaseyi (Vasey's pondweed)	1970	1	19	5%	S2	G4	SC	
Primula mistassinica (bird's-eye primrose)	1995	4	42	10%	S3	G5	SC	
Rhexia virginica (Virginia meadow-beauty)	2007	17	22	77%	S3	G5	SC	
Rhododendron lapponicum (Lapland azalea)	1991	1	2	50%	S1	G5	END	
Scirpus torreyi (Torrey's bulrush)	1998	3	21	14%	S2	G5?	SC	
Scleria reticularis (reticulated nutrush)	2007	4	4	100%	S1	G4	END	
Scleria triglomerata (whip nutrush)	1997	7	17	41%	S2S3	G5	SC	
Solidago sciaphila (shadowy goldenrod)	1997	19	57	33%	S3	G3G4	SC	
Strophostyles leiosperma (small-flowered woolly bean)	1997	3	6	50%	S2	G5	SC	
Talinum rugospermum (prairie fame-flower)	1999	8	54	15%	S3	G3G4	SC	
Thelypteris simulata (bog fern)	2006	66	72	92%	S3	G4G5	SC	
Utricularia geminiscapa (hidden-fruited bladderwort)	2007	23	95	24%	S3	G4G5	SC	
Utricularia purpurea (purple bladderwort)	1998	1	55	2%	S3	G5	SC	
Viola fimbriatula (sand violet)	1997	14	17	82%	S2	G5T5	END	
COMMUNITIES								
Alder Thicket	1997	19	106	18%	S4	G4	NA	
Black Spruce Swamp	1997	1	41	2%	S3?	G5	NA	
Calcareous Fen	1997	2	84	2%	S3	G3	NA	
Central Poor Fen	2007	30	30	100%	S3	G3G4	NA	
Central Sands Pine-Oak Forest	2007	11	11	100%	S3	G3	NA	
Coastal Plain Marsh	2000	2	6	33%	S1	G2?	NA	

Appendix 10.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in CSP	EOs in WI	Percent in CSP	State rank	Global rank	State status	Federal status
Dry Cliff	2002	14	88	16%	S4	G4G5	NA	
Dry Prairie	1981	8	146	5%	S3	G3	NA	
Dry-mesic Prairie	1999	1	37	3%	S2	G3	NA	
Emergent Marsh	1998	6	272	2%	S4	G4	NA	
Floodplain Forest	2001	24	182	13%	S3	G3?	NA	
Forested Seep	1997	1	15	7%	S2	GNR	NA	
Hardwood Swamp	1997	1	53	2%	S3	G4	NA	
Hemlock Relict	1997	5	32	16%	S2	G2Q	NA	
Lake—Oxbow	1978	1	14	7%	SU	GNR	NA	
Lake—Shallow, Hard, Seepage	1980	1	52	2%	SU	GNR	NA	
Lake—Shallow, Soft, Seepage	2004	1	87	1%	S4	GNR	NA	
Mesic Prairie	1989	1	44	2%	S1	G2	NA	
Moist Cliff	2001	17	176	10%	S4	GNR	NA	
Moist Sandy Meadow	1999	1	3	33%	SU	GNR	NA	
Northern Dry Forest	1998	21	63	33%	S3	G3?	NA	
Northern Dry-mesic Forest	2005	55	284	19%	S3	G4	NA	
Northern Mesic Forest	1992	7	383	2%	S4	G4	NA	
Northern Sedge Meadow	2005	44	231	19%	S3	G4	NA	
Northern Wet Forest	1999	29	322	9%	S4	G4	NA	
Northern Wet-mesic Forest	1980	2	243	1%	S3S4	G3?	NA	
Oak Barrens	1997	10	38	26%	S2	G2?	NA	
Open Bog	1997	7	173	4%	S4	G5	NA	
Pine Barrens	1999	25	56	45%	S2	G2	NA	
Pine Relict	1999	5	61	8%	S2	G4	NA	
Sand Barrens	1997	4	29	14%	SU	GNR	NA	
Sand Prairie	1999	4	28	14%	S2	GNR	NA	
Shrub-carr	2007	16	143	11%	S4	G5	NA	
Southern Dry Forest	1997	5	97	5%	S3	G4	NA	
Southern Dry-mesic Forest	2006	20	293	7%	S3	G4	NA	
Southern Mesic Forest	1997	5	221	2%	S3	G3?	NA	
Southern Sedge Meadow	1989	7	182	4%	S3	G4?	NA	
Southern Tamarack Swamp (Rich)	2007	1	32	3%	S3	G3	NA	
Springs and Spring Runs, Hard	1995	4	71	6%	S4	GNR	NA	
Stream—Fast, Hard, Cold	1995	14	98	14%	S4	GNR	NA	
Stream—Fast, Soft, Cold	1987	2	15	13%	SU	GNR	NA	
Stream—Fast, Soft, Warm	1997	2	5	40%	SU	GNR	NA	
Stream—Slow, Hard, Cold	1981	3	22	14%	SU	GNR	NA	
Stream—Slow, Hard, Warm	1981	2	20	10%	SU	GNR	NA	
Stream—Slow, Soft, Cold	1981	2	8	25%	SU	GNR	NA	
Stream—Slow, Soft, Warm	1983	1	14	7%	SU	GNR	NA	
Tamarack (Poor) Swamp	2005	10	33	30%	S3	G4	NA	
White Pine-Red Maple Swamp	2005	19	21	90%	S2	G3G4	NA	
OTHER ELEMENTS								
Bat hibernaculum	2000	1	43	2%	S3	GNR	SC	
Bird rookery	2000	5	54	9%	SU	G5	SC	
Migratory bird concentration site	2003	1	8	13%	SU	G3	SC	

[a]An element occurrence is an area of land and/or water in which a rare species or natural community is, or was, present. Element occurrences must meet strict criteria that is used by an international network of Heritage programs and coordinated by NatureServe.
[b]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.
[c]The American Ornithologist's Union lists these bird names as Cerulean Warbler (*Setophaga cerulea*), Kentucky Warbler (*Geothlypis formosa*), and Kirtland's Warbler (*Setophaga kirtlandii*), and Louisiana Waterthrush (*Parkesia motacilla*).

Appendix 17.C, *continued.*

STATUS AND RANKING DEFINITIONS

U.S. Status—Current federal protection status designated by the Office of Endangered Species, U.S. Fish and Wildlife Service, indicating the biological status of a species in Wisconsin:

LE = listed endangered.
LT = listed threatened.
PE = proposed as endangered.
NEP = nonessential experimental population.
C = candidate for future listing.
CH = critical habitat.

State Status—Protection category designated by the Wisconsin DNR:

END = Endangered. Endangered species means any species whose continued existence as a viable component of this state's wild animals or wild plants is determined by the Wisconsin DNR to be in jeopardy on the basis of scientific evidence.
THR = Threatened species means any species of wild animals or wild plants that appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.
SC = Special Concern. Special Concern species are those species about which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Wisconsin DNR and federal regulations regarding Special Concern species range from full protection to no protection. The current categories and their respective level of protection are as follows:
SC/P = fully protected;
SC/N = no laws regulating use, possession, or harvesting;
SC/H = take regulated by establishment of open closed seasons;
SC/FL = federally protected as endangered or threatened but not so designated by Wisconsin DNR;
SC/M = fully protected by federal and state laws under the Migratory Bird Act.

Global Element Ranks:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state or physiographic region) or because of other factor(s) making it vulnerable to extinction throughout its range; typically 21-100 occurrences.
G4 = Uncommon but not rare (although it may be quite rare in parts of its range, especially at the periphery) and usually widespread. Typically > 100 occurrences.
G5 = Common, widespread, and abundant (although it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.
GH = Known only from historical occurrence throughout its range, with the expectation that it may be rediscovered.
GNR = Not ranked. Replaced G? rank and some GU ranks.
GU = Currently unrankable due to lack of data or substantially conflicting data on status or trends. Possibly in peril range-wide, but status is uncertain.
GX = Presumed to be extinct throughout its range (e.g., Passenger pigeon) with virtually no likelihood that it will be rediscovered.

Species with a questionable taxonomic assignment are given a "Q" after the global rank. Subspecies and varieties are given subranks composed of the letter "T" plus a number or letter. The definition of the second character of the subrank parallels that of the full global rank. (Examples: a rare subspecies of a rare species is ranked G1T1; a rare subspecies of a common species is ranked G5T1.)

State Element Ranks:

S1 = Critically imperiled in Wisconsin because of extreme rarity, typically 5 or fewer occurrences and/or very few (<1,000) remaining individuals or acres, or due to some factor(s) making it especially vulnerable to extirpation from the state.
S2 = Imperiled in Wisconsin because of rarity, typically 6–20 occurrences and/or few (1,000– 3,000) remaining individuals or acres, or due to some factor(s) making it very vulnerable to extirpation from the state.
S3 = Rare or uncommon in Wisconsin, typically 21–100 occurrences and/or 3,000–10,000 individuals.
S4 = Apparently secure in Wisconsin, usually with > 100 occurrences and > 10,000 individuals.
S5 = Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.
SNA = Accidental, nonnative, reported but unconfirmed, or falsely reported.
SH = Of historical occurrence in Wisconsin, perhaps having not been verified in the past 20 years and suspected to be still extant. Naturally, an element would become SH without such a 20-year delay if the only known occurrence were destroyed or if it had been extensively and unsuccessfully looked for.
SNR = Not Ranked; a state rank has not yet been assessed.
SU = Currently unrankable. Possibly in peril in the state, but status is uncertain due to lack of information or substantially conflicting data on status or trends.
SX = Apparently extirpated from the state.

State ranking of long-distance migrant animals:

Ranking long distance aerial migrant animals presents special problems relating to the fact that their nonbreeding status (rank) may be quite different from their breeding status, if any, in Wisconsin. In other words, the conservation needs of these taxa may vary between seasons. In order to present a less ambiguous picture of a migrant's status, it is necessary to specify whether the rank refers to the breeding (B) or nonbreeding (N) status of the taxon in question. (e.g. S2B,S5N).

Appendix 10.D. *Number of species with special designations documented within the Central Sand Plains Ecological Landscape.*

Listing status	Taxa					Total fauna	Total flora	Total listed
	Mammals	Birds	Herptiles	Fishes	Invertebrates			
U.S. Endangered	1	1	0	0	1	3	0	3
U.S. Threatened	0	0	0	0	0	0	0	0
U.S. Candidate	0	0	1	0	1	2	0	2
Wisconsin Endangered	0	4	4	0	5	13	6	19
Wisconsin Threatened	0	9	2	5	4	20	8	28
Wisconsin Special Concern	6	16	5	6	50	83	41	124
Natural Heritage Inventory total	**6**	**29**	**11**	**11**	**59**	**116**	**55**	**171**

Note: Wisconsin-listed species always include federally listed species (although they may not be the same designation); therefore, federally listed species are not included in the total.

Appendix 10.E. *Species of Greatest Conservation Need (SGCN) found in the Central Sand Plains Ecological Landscape.*

These SGCNs have a high or moderate probability of being found in this ecological landscape and use habitats that have the best chance for management here. Data are from the Wisconsin Wildlife Action Plan (Wisconsin DNR 2005b) and Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 of this book ("Supporting Materials"). For more complete and/or detailed information, please see the Wisconsin Wildlife Action Plan. The Wildlife Action Plan is meant to be dynamic and will be periodically updated to reflect new information; the next update is planned for 2013–2015.

Only SGCNs highly or moderately (H = high association, M = moderate association) associated with specific community types or other habitat types and which have a high or moderate probability of occurring in the ecological landscape are included here (SGCNs with a low affinity with a community type or other habitat type and with low probability of being associated with this ecological landscape were excluded). Only community types designated as "Major" or "Important" management opportunities for the ecological landscape are shown.


Eastern Meadowlark. Photo by Herbert Lange.

	MAJOR															IMPORTANT																
	Alder Thicket	Central Sands Pine - Oak Forest	Dry Cliff	Floodplain Forest	Impoundments/Reservoirs	Northern Sedge Meadow	Northern Wet Forest	Oak Barrens	Open Bog	Pine Barrens	Sand Prairie	Shrub Carr	Southern Dry-mesic Forest	Surrogate Grasslands	White Pine - Red Maple Swamp	Coastal Plain Marsh	Coldwater streams	Coolwater streams	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Moist Cliff	Northern Dry Forest	Northern Dry-mesic Forest	Northern Hardwood Swamp	Northern Mesic Forest	Southern Dry Forest	Southern Mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (Rich)	Submergent Marsh	Warmwater rivers	Warmwater streams
Species That Are Significantly Associated with the Central Sand Plains Ecological Landscape																																
MAMMALS																																
Franklin's ground squirrel								H		H	H			M						H												
Gray wolf	H	H		M			H	M	M	M		M	M										M	H	M	H	M	M				
BIRDS[a]																																
American Bittern						H			H												H							M				
American Woodcock	H											H													M	M			M			
Bald Eagle					H																									M	H	
Black Tern					M	M															H									M		
Black-billed Cuckoo	H			M				M		M		H														M			M			
Blue-winged Teal				M	M	M								M						M	H							M		M		
Blue-winged Warbler				M								M	M														M	M		M			
Bobolink						H			M					H						H									M				
Brown Thrasher								H		H	H			M					M	M												
Dickcissel														H						H												
Eastern Meadowlark											M			H					M	H									M			
Field Sparrow								M		M	H			M					H	M												
Golden-winged Warbler	H						M		M			H											M	M	M	M						
Grasshopper Sparrow								M			H			H					H	H												
Greater Prairie-Chicken						M								H					M	H								M				
Henslow's Sparrow									M					H						H												
Least Flycatcher				M																			M	M	M	H						
Lesser Scaup					M																									H	M	
Northern Harrier						H		M	M	M				H					M	M								M				
Osprey					H																										H	
Prothonotary Warbler				H																												
Red-headed Woodpecker		M		M				M					M														M					
Red-shouldered Hawk				H									M		M									M		M		M				

Appendix 10.E, *continued.*


Lark Sparrow. Photo by Gary Kramer, USFWS.

	MAJOR															IMPORTANT																
	Alder Thicket	Central Sands Pine - Oak Forest	Dry Cliff	Floodplain Forest	Impoundments/Reservoirs	Northern Sedge Meadow	Northern Wet Forest	Oak Barrens	Open Bog	Pine Barrens	Sand Prairie	Shrub Carr	Southern Dry-mesic Forest	Surrogate Grasslands	White Pine - Red Maple Swamp	Coastal Plain Marsh	Coldwater streams	Coolwater streams	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Moist Cliff	Northern Dry Forest	Northern Dry-mesic Forest	Northern Hardwood Swamp	Northern Mesic Forest	Southern Dry Forest	Southern Mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (Rich)	Submergent Marsh	Warmwater rivers	Warmwater streams
Short-billed Dowitcher					M																H												
Short-eared Owl						M						M		H					M	M								M				
Trumpeter Swan					M																H										H		
Upland Sandpiper								M		M	M			H					H	H												
Veery	H			M			M					H	M		H									M	H	M		M					
Vesper Sparrow								H		H	H								H	M												
Western Meadowlark								M			M			H					M	H												
Whip-poor-will		H						M		M			H										M	M			H					
Whooping Crane						M			M												H							M		H		
Willow Flycatcher												H		M						M								M				
Wood Thrush				M									H													M	M	H				
Yellow-billed Cuckoo				H								M	M															M				
HERPTILES																																
Blanding's turtle	M			M	H	M		H		H	H	M	M			M	M	M	H	M	H							M	H	M	H	M	M
Four-toed salamander	H			H		M	M		H			H					M	M			H				M	H		H	M	M			
Mudpuppy					H												M	M													H	
Western slender glass lizard								H		H	H								H	H												
Wood turtle	H			H		M	M	H		H	H	H					H	H	H	M					M	H		M	M			H	H
FISH																																
Lake sturgeon					H																										H	
Species That Are Moderately Associated with the Central Sand Plains Ecological Landscape																																
MAMMALS																																
Eastern red bat	M	M		M		M	M	M	M			M	M		M	M	H	H			M		M	M	M	M	M	M		M	M	M
Hoary bat	M	M		M		M	M		M			M			M	M	H	H			M		M	M	M	M		M		M	M	M
Northern long-eared bat	M	M		M		M		M	M			M	M		M	M	H	H			M		M	M	M	M	M	M	M		M	M	M
Prairie vole								M			H			M					H	H													
Silver-haired bat	M	M		M		M	M		M			M			M	M	H	H			M		M	M	M	M		M		M	M	M
Water shrew	M			M			H										H	H							H	M		M				M
White-tailed jackrabbit											H			M					H	H												
BIRDS																																
American Golden Plover					M									M						M	M											
Canada Warbler	M						M								M									M	H	M						
Canvasback					M																									H	H	
Cerulean Warbler				H									H														M					
Connecticut Warbler							M		M	M													H									
Dunlin					M																M										M	
Hudsonian Godwit																					H											
King Rail																					H								M			
Lark Sparrow								H		M	H								M													

Continued on next page

Appendix 10.E, *continued.*


Red Crossbill. Photo by Dave Menke, USFWS.

	MAJOR															IMPORTANT																
	Alder Thicket	Central Sands Pine - Oak Forest	Dry Cliff	Floodplain Forest	Impoundments/Reservoirs	Northern Sedge Meadow	Northern Wet Forest	Oak Barrens	Open Bog	Pine Barrens	Sand Prairie	Shrub Carr	Southern Dry-mesic Forest	Surrogate Grasslands	White Pine - Red Maple Swamp	Coastal Plain Marsh	Coldwater streams	Coolwater streams	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Moist Cliff	Northern Dry Forest	Northern Dry-mesic Forest	Northern Hardwood Swamp	Northern Mesic Forest	Southern Dry Forest	Southern Mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (Rich)	Submergent Marsh	Warmwater rivers	Warmwater streams
Le Conte's Sparrow						H			M					H																		
Louisiana Waterthrush													H				H	H									H				
Northern Goshawk															M									M		H						
Red Crossbill										M													H	H								
Red-necked Grebe																					H									M		
Rusty Blackbird	M			H					M			M									M								M			
Sharp-tailed Grouse						M		H		H				M					M	M												
Solitary Sandpiper				H					M							M	M	M			H											M
Wilson's Phalarope						H															H									M		
Yellow Rail						H			H																							
HERPTILES																																
Bullsnake		M	H					H		H	H		M						H	H						M	M				
Eastern massasauga rattlesnake	H			H				H	H	H	H	H							H	H	M							H			
Midland smooth softshell turtle																															H	
Pickerel frog	M			M	H	H	M		M			M					H	H			H					M		M	H		H	M	M
Prairie ringneck snake		M	H					M			M		M						H	H							M					
Yellow-bellied racer			H					M		M	H		M						H	M							M					
FISH																																
River redhorse																															M	
Western sand darter																															M	

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 10.F. *Natural communities[a] for which there are management opportunities in the Central Sand Plains Ecological Landscape.*

Major opportunity[b]	Important opportunity[c]	Present[d]
Northern Wet Forest	Northern Dry Forest	Hemlock Relict
Southern Dry-Mesic Forest	Northern Dry-Mesic Forest	Pine Relict
Central Sands Pine – Oak Forest	Northern Mesic Forest	
Floodplain Forest	Northern Hardwood Swamp	Oak Woodland
White Pine – Red Maple Swamp	Southern Dry Forest	Cedar Glade
	Southern Mesic Forest	
Pine Barrens	Southern Tamarack Swamp	Mesic Prairie
Oak Barrens		Wet-Mesic Prairie
	Dry Prairie	Wet Prairie
Alder Thicket	Dry-Mesic Prairie	
Open Bog	Southern Sedge Meadow	Calcareous Fen (Southern)
Shrub Carr		
	Emergent Marsh	Bedrock Glade
Sand Prairie	Submergent Marsh	
Northern Sedge Meadow	Coastal Plain Marsh	Inland Lake
Surrogate Grasslands		
	Moist Cliff (Curtis's Shaded Cliff)	
Dry Cliff (Curtis's Exposed Cliff)		
Impoundment/Reservoir	Coldwater Stream	
	Coolwater Stream	
	Warmwater River	
	Warmwater Stream	

[a]See Chapter 7, "Natural Communities, Aquatic Features, and Other Selected Habitats of Wisconsin," in Part 1 of the book for definitions of natural community types. Also see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 of the book ("Supporting Materials") for an explanation on how the information in this table can be used.

[b]Major opportunity – Relatively abundant, represented by multiple significant occurrences, or ecological landscape is appropriate for major restoration activities.

[c]Important opportunity – Less abundant but represented by one to several significant occurrences or type is restricted to one or a few ecological landscapes.

[d]Present – Uncommon or rare, with no good occurrences documented. Better opportunities are known to exist in other ecological landscapes, or opportunities have not been adequately evaluated.

Appendix 10.G. *Public conservation lands in the Central Sand Plains Ecological Landscape, 2005.*

Property name	Size (acres)[a]
STATE	
Augusta State Wildlife Area[b]	380
Big Roche A Cri State Fishery Area	810
Black River State Forest[b]	65,930
Buckhorn State Park	2,610
Buckhorn State Wildlife Area	4,380
Buena Vista State Wildlife Area	7,740
Colburn State Wildlife Area	5,050
Dell Creek State Wildlife Area[b]	770
Dells of the Wisconsin River State Natural Area	1,370
Dewey Marsh State Wildlife Area[b]	4,960
Hulburt Creek State Fishery Area[b]	590
Jay Creek State Natural Area	360
Leola Marsh State Wildlife Area	1,870
Little Plover River State Fishery Area	245
Meadow Valley State Wildlife Area	58,040
Mill Bluff State Park[b]	1,150
Mirror Lake State Park	2,150
Paul Olson State Wildlife Area[b]	780
Quincy Bluff And Wetlands State Natural Area	4,870
Roche A Cri State Park	460
Rocky Arbor State Park	230
Sandhill State Wildlife Area	9,480
Wood County State Wildlife Area	1,070
Miscellaneous Lands[c]	4,175
FEDERAL	
Necedah National Wildlife Refuge	39,580
COUNTY FOREST[d]	
Clark County Forest[b]	123,300
Eau Claire County Forest[b]	41,340
Jackson County Forest[b]	118,130
Juneau County Forest[b]	14,950
Monroe County Forest[b]	3,500
Wood County Forest	37,570
TOTAL	**557,840**

Source: Wisconsin Land Legacy Report (Wisconsin DNR 2006c).

[a]Actual acres owned in this ecological landscape.

[b]This property also falls within adjacent ecological landscape(s).

[c]Includes public access sites, fish hatcheries, fire towers, streambank and nonpoint easements, lands acquired under statewide wildlife, fishery, forestry, and natural area programs, Board of Commissioners of Public Lands holdings, small properties under 100 acres, and properties with fewer than 100 acres within this ecological landscape.

[d]Locations and sizes of county-owned parcels enrolled in the Forest Crop Law are presented here. Information on locations and sizes of other county and local parks in this ecological landscape is not readily available and is not included here, except for some very large properties.

Appendix 10.H. *Land Legacy Places in the Central Sand Plains Ecological Landscape.*

The *Wisconsin Land Legacy Report* (Wisconsin DNR 2006c) identified 16 places in the Central Sand Plains Ecological Landscape that merit conservation attention based upon a combination of ecological significance and recreational potential. Cranmoor Wetlands is an additional site worthy of future consideration. Though hydrologically altered by extensive dike construction, this vast wetland complex now supports rare birds and herptiles and has the potential to support rare plants.

Code	Place name	Size	Protection initiated	Protection remaining	Conservation significance[a]	Recreation potential[b]
BF	Bear Bluff	Large	Limited	Substantial	xxxxx	x
BR	Black River	Large	Moderate	Moderate	xxxxx	xxxxx
CF	Central Wisconsin Forests	Large	Substantial	Limited	xxxxx	xxxx
CG	Central Wisconsin Grasslands	Large	Moderate	Moderate	xxxxx	xxx
CU	Colburn – Richfield Wetlands	Small	Substantial	Limited	xxx	xx
DW	Dewey Marsh and Woods	Small	Moderate	Limited	xxx	xxx
GC	Greensand Cuesta	Medium	Limited	Moderate	xxx	xxx
LV	Little Plover River	Small	Moderate	Moderate	xx	xxx
LL	Lower Lemonweir River	Medium	Limited	Substantial	xxx	xx
MW	Middle Wisconsin River	Large	Limited	Moderate	xx	xxxxx
NC	Necedah National Wildlife Refuge	Medium	Substantial	Limited	xxxxx	xxx
PV	Plover River	Medium	Limited	Substantial	xxx	xxx
QB	Quincy Bluff	Medium	Substantial	Moderate	xxxxx	xxx
RN	Robinson Creek Barrens	Medium	Substantial	Limited	xxxxx	xxx
SM	Sandhill-Meadow Valley-Wood County State Wildlife Areas	Large	Substantial	Limited	xxxxx	xxx
YW	Yellow (Wisconsin) River	Large	Moderate	Moderate	xxxxx	xx

[a]Conservation significance. See the *Wisconsin Land Legacy Report* (Wisconsin DNR 2006c), p. 43, for detailed discussion.

- xxxxx Possesses outstanding ecological qualities, is large enough to meet the needs of critical components, and/or harbors globally or continentally significant resources. Restoration, if needed, has a high likelihood of success.
- xxxx Possesses excellent ecological qualities, is large enough to meet the needs of most critical components, and/or harbors continentally or Great Lakes regionally significant resources. Restoration has a high likelihood of success.
- xxx Possesses very good ecological qualities, is large enough to meet the needs of some critical components, and/or harbors statewide significant resources. Restoration will typically be important and has a good likelihood of success.
- xx Possesses good ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors statewide or ecological landscape significant resources. Restoration is likely needed and has a good chance of success.
- x Possesses good to average ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors ecological landscape significant resources. Restoration is needed and has a reasonable chance of success.

[b]Recreation potential. See the *Wisconsin Land Legacy Report*, p. 43, for detailed discussion.

- xxxxx Outstanding recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet many current and future recreation needs, is large enough to accommodate incompatible activities, could link important recreation areas, and/or is close to state's largest population centers.
- xxxx Excellent recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet several current and future recreation needs, is large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to large population centers.
- xxx Very good recreation potential, could offer a variety of land and/or water-based recreation opportunities, could meet some current and future recreation needs, may be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized to large population centers.
- xx Good to moderate recreation potential, could offer some land and/or water-based recreation opportunities, might meet some current and future recreation needs, may not be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized population centers.
- x Limited recreation potential, could offer a few land and/or water-based recreation opportunities, might meet some current and future recreation needs, is not likely large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to small population centers.

Appendix 10.I. *Importance of economic sectors (based on the number of jobs) within the Central Sand Plains (CSP) counties compared to the rest of the state.*

Industry	CLMC	CSH	CSP	FT	NCF	NES	NH	NLMC	NWL	NWS	SEGP	SLMC	SWS	SCP	WCR	WP
Agriculture, Fishing & Hunting	0.87	2.14	2.41	2.15	2.15	1.90	0.50	2.71	0.43	1.29	0.76	0.10	4.46	0.87	2.36	2.30
Forest Products & Processing	1.64	0.98	1.83	2.40	3.43	2.20	1.33	1.74	0.41	1.07	0.65	0.32	0.45	1.44	0.96	0.69
Mining	1.08	1.64	0.79	0.79	2.69	3.55	0.91	2.16	0.16	0.34	1.47	0.19	0.62	0.08	0.77	1.21
Utilities	2.44	1.08	0.81	0.39	0.61	0.45	0.58	0.41	1.96	1.76	0.67	0.65	0.81	1.83	1.19	0.51
Construction	1.12	1.02	0.89	0.96	1.14	0.92	2.38	1.08	1.07	1.14	1.08	0.67	0.98	1.13	1.03	1.11
Manufacturing (non-wood)	1.23	1.02	0.74	0.98	0.90	1.37	0.21	1.15	0.49	0.59	1.19	0.87	0.78	0.46	0.77	0.99
Wholesale Trade	0.99	0.63	0.61	0.95	0.62	0.53	0.47	0.60	1.15	0.72	1.16	0.98	0.89	0.76	0.83	0.53
Retail Trade	1.01	1.00	0.99	1.11	1.11	1.00	1.66	1.03	1.30	1.19	1.02	0.80	1.69	1.11	1.11	1.13
Tourism-related	0.99	1.12	0.97	0.86	0.99	1.05	1.51	1.28	1.34	1.41	0.94	1.02	0.78	1.33	1.08	1.12
Transportation & Warehousing	0.95	1.32	2.13	1.40	1.19	1.15	0.80	0.89	3.25	2.15	0.82	0.83	0.74	2.12	1.39	0.99
Information	0.76	0.49	0.69	0.74	0.58	0.68	0.80	0.70	0.38	0.49	1.22	1.11	1.09	0.64	0.62	0.57
Finance & Insurance	1.22	1.31	0.89	0.96	0.56	0.46	0.43	0.48	0.47	0.46	1.04	1.18	0.65	0.45	0.70	0.55
Real Estate, Rental & Leasing	0.84	0.73	0.59	0.60	0.52	0.34	1.37	0.95	0.42	0.50	1.17	1.14	0.47	0.46	0.87	0.66
Pro, Science & Tech Services	0.85	0.53	0.46	0.55	0.41	0.36	0.43	0.45	0.51	0.47	1.04	1.51	0.49	0.47	0.63	0.81
Management	0.80	0.26	0.63	0.54	0.37	0.21	0.17	0.24	0.65	0.47	0.94	1.62	0.08	0.64	0.87	0.45
Admin, Support, Waste, & Remediation	0.99	0.42	0.43	0.46	0.34	0.23	0.61	0.34	0.61	0.43	0.92	1.64	0.58	0.51	0.70	0.63
Private Education	0.86	0.68	0.39	0.42	0.86	0.72	0.87	0.55	0.08	0.12	0.80	1.94	0.09	1.53	0.68	0.55
Health Care & Social Services	0.85	0.88	1.27	1.04	0.82	0.90	0.87	0.84	0.96	0.91	0.83	1.32	0.84	0.99	1.09	0.94
Other Services	1.08	1.32	1.10	1.05	1.10	1.13	1.25	1.19	1.36	1.09	1.06	0.84	1.14	1.13	0.91	1.29
Government	0.78	1.09	1.11	1.03	1.26	1.36	1.08	1.03	1.36	1.54	1.04	0.89	1.15	1.50	1.14	1.21

Source: Based on an economic base analysis (Quintero 2007). Definitions of economic sectors can be found at the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

Appendix 10.J. *Scientific names of species mentioned in the text.*

Common name	Scientific name
Acadian Flycatcher[a]	*Empidonax virescens*
Alder Flycatcher	*Empidonax alnorum*
American beaver	*Castor canandensis*
American Bittern	*Botaurus lentiginosus*
American Black bear	*Ursus americanus*
American Woodcock	*Scolopax minor*
Annosum root rot fungus	*Heterobasidion annosum*
Aspen	*Populus* spp.
Aspen heart rot fungus	*Phellinus tremulae*
Aspen hypoxylon canker fungus	*Hypoxylon mammatum*
Assiniboine sedge	*Carex assiniboinensis*
Badger	*Taxidea taxus*
Bald Eagle	*Haliaeetus leucocephalus*
Barn Owl	*Tyto alba*
Beak grass	*Diarrhena americana*
Bearberry	*Arctostaphylos uva-ursi*
Bell's Vireo	*Vireo bellii*
Big-tooth aspen	*Populus grandidentata*
Black cherry	*Prunus serotina*
Black oak	*Quercus velutina*
Black spruce	*Picea mariana*
Black Tern	*Chlidonias niger*
Blackburnian Warbler	*Setophaga fusca*
Black-throated Green Warbler	*Setophaga virens*
Blanding's turtle	*Emydoidea blandingii*
Blue sucker	*Cycleptus elongatus*
Blueberry	*Vaccinium angustifolium*
Bluegill	*Lepomis macrochirus*
Blue-headed Vireo	*Vireo solitarius*
Bobolink	*Dolichonyx oryzivorus*
Bog birch	*Betula pumila*
Bog bluegrass	*Poa paludigena*
Bog fern	*Thelypteris simulata*
Brook trout	*Salvelinus fontinalis*
Brown Thrasher	*Toxostoma rufum*
Brown trout	*Salmo trutta*
Brown-headed Cowbird	*Molothrus ater*
Buckhorn mussel	*Tritogonia verrucos*
Buckmoths	Hemileuca spp.
Bullhead (sheepnose) mussel	*Plethobasus cyphyus*
Bur oak	*Quercus macrocarpa*
Canada bluegrass	*Poa compressa*
Canada Goose	*Branta canadensis*
Canada Warbler	*Cardellina canadensis,* listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List
Catfoot	*Gnaphalium helleri* var. *micradenium*
Cerulean Warbler	*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List
Chokeberry	*Aronia melanocarpa*
Clay-colored Sparrow	*Spizella pallida*
Cliff cudweed	*Gnaphalium obtusifolium* var. *saxicola*
Club-spur orchid	*Platanthera clavellata*
Clustered sedge	*Carex cumulata*
Common carp	*Cyprinus carpio*
Common Loon	*Gavia immer*

Continued on next page

Appendix 10.J, *continued.*

Common name	Scientific name
Common Nighthawk	*Chordeiles minor*
Common Raven	*Corvus corax*
Common reed	*Phragmites australis*
Connecticut Warbler	*Oporornis agilis*
Creeping-Charlie	*Glechoma hederacea*
Crossleaf milkwort	*Polygala cruciata*
Curly pondweed	*Potamogeton crispus*
Cylindrical blazing-star	*Liatris cylindracea*
Cypress spurge	*Euphorbia cyparissias*
Diplodia pine blight fungus	*Diplodia pinea*
Dogwoods	*Cornus* spp.
Dutch elm disease fungus	*Ophiostoma ulmi*
Dwarf milkweed	*Asclepias ovalifolia*
Early anemone	*Anemone multifida* var. *hudsoniana*
Eastern Bluebird	*Sialia sialis*
Eastern cottonwood	*Populus deltoides*
Eastern hemlock	*Tsuga canadensis*
Eastern larch beetle	*Dendroctonus simplex*
Eastern massasauga rattlesnake	*Sistrurus catenatus catenatus*
Eastern Meadowlark	*Sturnella magna*
Eastern Towhee	*Pipilo erythrophthalmus*
Eastern Whip-poor-will	*Caprimulgus vociferus*
Eastern white pine	*Pinus strobus*
Emerald ash borer	*Agrilus planipennis*
Eurasian honeysuckles	*Lonicera tatarica, Lonicera* x *bella, L. morrowii*
Eurasian water-milfoil	*Myriophyllum spicatum*
Fameflower	*Talinum rugospermum*
Field Sparrow	*Spizella pusilla*
Fisher	*Martes pennanti*
Forest tent caterpillar	*Malacosoma disstria*
Forster's Tern	*Sterna forsteri*
Frosted elfin	*Callophrys irus*
Garlic mustard	*Alliaria petiolata*
Gilt darter	*Percina evides*
Glossy buckthorn	*Rhamnus frangula*
Golden-crowned Kinglet	*Regulus satrapa*
Golden-winged Warbler	*Vermivora chrysoptera*
Gophersnake	*Pituophis catenifer*
Grass pink	*Calopogon tuberosus*
Grasshopper Sparrow	*Ammodramus savannarum*
Grassleaf rush	*Juncus marginatus*
Gray wolf	*Canis lupus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Greater Prairie-chicken	*Tympanuchus cupido*
Green ash	*Fraxinus pennsylvanica*
Gypsy moth	*Lymantria dispar*
Hackberry	*Celtis occidentalis*
Hazelnuts	*Corylus* spp.
Henslow's Sparrow	*Ammodramus henslowii*
Hermit Thrush	*Catharus guttatus*
Huckleberry	*Gaylussacia baccata*
Hybrid cat-tail	*Typha* x *glauca*
Jack pine	*Pinus banksiana*
Jack pine budworm	*Choristoneura pinus*

Appendix 10.J, *continued.*

Common name	Scientific name
Kalm's St. John's wort	*Hypericum kalmianum*
Karner blue butterfly	*Lycaeides Melissa samuelis*
Kentucky bluegrass	*Poa pratensis*
Kentucky Warbler	*Geothlypis formosa,* listed as *Oporornis formosus* on the Wisconsin Natural Heritage Working List
Kirtland's Warbler	*Setophaga kirtlandii,* listed as *Dendroica kirtlandii* on the Wisconsin Natural Heritage Working List
Labrador tea	*Ledum groenlandicum*
Lake sturgeon	*Acipenser fulvescens*
Lance-leaved loosestrife	*Lysimachia lanceolata*
Lance-leaved violet	*Viola lanceolata*
Lapland azalea	*Rhododendron lapponicum*
Larch casebearer	*Coleophora laricella*
Larch sawfly	*Pristiphora erichsonii*
Largemouth bass	*Micropterus salmoides*
Le Conte's Sparrow	*Ammodramus leconteii*
Leafy spurge	*Euphorbia esula*
Lincoln's Sparrow	*Melospiza lincolnii*
Loggerhead Shrike	*Lanius ludovicianus*
Long sedge	*Carex folliculata*
Long-leaved aster	*Aster longifolius*
Louisiana Waterthrush	*Parkesia motacilla*, listed as *Seiurus motacilla* on the Wisconsin Natural Heritage Working List
Maidenhair spleenwort	*Asplenium trichomanes*
Massachusetts fern	*Thelypteris simulata*
Meadow beauty	*Rhexia virginica*
Merlin	*Falco columbarius*
Midland smooth softshell turtle	*Apalone muticus*
Moneywort	*Lysimachia nummularia*
Mourning Warbler	*Geothlypis philadelphia*
Muskellunge	*Esox masquinongy*
Nashville Warbler	*Oreothlypis ruficapilla*
North American racer	*Coluber constrictor*
North American river otter	*Lutra canadensis*
Northern bog clubmoss	*Lycopodium inundatum*
Northern cricket frog	*Acris crepitans*
Northern Goshawk	*Accipiter gentilis*
Northern Harrier	*Circus cyaneus*
Northern Parula	*Setophaga americana*
Northern pin oak	*Quercus ellipsoidalis*
Northern prostrate clubmoss	*Lycopodiella margueritae*
Northern red oak	*Quercus rubra*
Northern Saw-whet Owl	*Aegolius acadicus*
Northern Waterthrush	*Parkesia noveboracensis*
Oak wilt fungus	*Ceratocystis fagacearum*
Orchard grass	*Dactylis glomerata*
Orchard Oriole	*Icterus spurius*
Ornate box turtle	*Terrapene ornata*
Passenger Pigeon	*Ectopistes migratorius*
Phlox moth	*Schinia indiana*
Pine sawfly	*Neodiprion* spp., *Diprion* spp.
Pocket gopher	*Geomys bursarius*
Pocket mortality fungal species	*Leptographium terrebrantis* and *L. procerum*
Prairie blazing star	*Liatris pycnostachya*
Prairie leafhopper	*Polyamia dilata*

Continued on next page

Appendix 10.J, *continued.*

Common name	Scientific name
Prairie willow	*Salix humilis*
Prothonotary Warbler	*Protonotaria citrea*
Purple loosestrife	*Lythrum salicaria*
Purple wartyback	*Cyclonaias tuberculata*
Quack grass	*Elytrigia repens*
Quaking aspen	*Populus tremuloides*
Red Crossbill	*Loxia curvirostra*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Red-breasted Nuthatch	*Sitta canadensis*
Redfin shiner	*Lythrurus umbratilis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-necked Grebe	*Podiceps grisegena*
Red-shouldered Hawk	*Buteo lineatus*
Redside dace	*Clinostomus elongatus*
Reed canary grass	*Phalaris arundinacea*
Regal fritillary	*Speyeria idalia*
Reticulated nutrush	*Scleria reticularis*
Ringed boghaunter dragonfly	*Williamsonia lintneri*
Ring-necked Duck	*Aythya collaris*
River birch	*Betula nigra*
River redhorse	*Moxostoma carinatum*
Rock clubmoss	*Huperzia porophila*
Rose pogonia	*Pogonia ophioglossoides*
Round-leaved sundew	*Drosera rotundifolia*
Ruffed Grouse	*Bonasa umbellus*
Rusty crayfish	*Orconectes rusticus*
Salamander mussel	*Simpsonaias ambigua*
Sand snaketail dragonfly	*Ophiogomphus smithi*
Sand violet	*Viola fimbriatula*
Sandhill Crane	*Grus canadensis*
Scrub oak	*Quercus velutina* and *Q. ellipsoidalis*
Sedge Wren	*Cistothorus platensis*
Serviceberry	*Amelanchier* spp.
Shadowy goldenrod	*Solidago sciaphila*
Sharp-shinned Hawk	*Accipiter striatus*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Shoal chub	*Macrhybopsis aestivalis*
Short-eared Owl	*Asio flammeus*
Shrubby cinquefoil	*Pentaphylloides floribunda*
Silver maple	*Acer saccharinum*
Slender glass lizard	*Ophisaurus attenuatus*
Smallmouth bass	*Micropterus dolomieu*
Smooth brome	*Bromus inermis*
Snowshoe hare	*Lepus americanus*
Sphagnum moss	*Sphagnum* spp.
Spotted knapweed	*Centaurea biebersteinii*
Steeplebush	*Spiraea tomentosa*
Straw sedge	*Carex straminea*
Sugar maple	*Acer saccharum*
Swamp-pink	*Arethusa bulbosa*
Sweet-fern	*Comptonia peregrina*
Sweet-scented Indian-plantain	*Cacalia suaveolens*
Tamarack	*Larix laricina*
Timothy	*Phleum pratense*

Appendix 10.J, *continued.*

Common name	Scientific name
Trumpeter Swan	*Cygnus buccinator*
Turkey Vulture	*Cathartes aura*
Twining screwstem	*Bartonia paniculata*
Two-lined chestnut borer	*Agrilus bilineatus*
Upland Sandpiper	*Bartramia longicauda*
Veery	*Catharus fuscescens*
Vesper Sparrow	*Pooecetes gramineus*
Walleye	*Stizostedion vitreum*
Warpaint emerald dragonfly	*Somatochlora incurvata*
Western sand darter	*Etheostoma clarum*
Wild Turkey	*Meleagris gallopavo*
White birch	*Betula papyrifera*
White colic-root	*Aletris farinosa*
White oak	*Quercus alba*
White pine blister rust	*Cronartium ribicola*
White-tailed deer	*Odocoileus virginianus*
White-throated Sparrow	*Zonotrichia albicollis*
Whooping Crane	*Grus americana*
Wild lupine	*Lupinus perennis*
Wild rice	*Zizania* spp.
Willows	*Salix* spp.
Wilson's Snipe	*Gallinago delicta*
Winter Wren	*Troglodytes hiemalis*
Winterberry holly	*Ilex verticillata*
Wood turtle	*Glyptemys insculpta*
Yellow perch	*Perca flavescens*
Yellow Rail	*Coturnicops noveboracensis*
Yellow screwstem	*Bartonia virginica*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-crowned Night-Heron	*Nyctanassa violacea*
Yellow-rumped Warbler	*Setophaga coronata*
Zebra mussel	*Dreissena polymorpha*

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 10.K. *Maps of important physical, ecological, and aquatic features within the Central Sand Plains Ecological Landscape.*

- Vegetation of the Central Sand Plains Ecological Landscape in the Mid-1800s
- Land Cover of the Central Sand Plains Ecological Landscape in the Mid-1800s
- Landtype Associations (LTAs) of the Central Sand Plains s Ecological Landscape
- Public Land Ownership, Easements, and Private Land Enrolled in Forest Tax Programs in the Central Sand Plains Ecological Landscape
- Ecologically Significant Places of the Central Sand Plains Ecological Landscape
- Exceptional and Outstanding Resource Waters and 303(d) Degraded Waters of the Central Sand Plains Ecological Landscape
- Dams of the Central Sand Plains Ecological Landscape
- WISCLAND Land Cover (1992) of the Central Sand Plains Ecological Landscape
- Soil Regions of the Central Sand Plains Ecological Landscape
- Relative Tree Density of the Central Sand Plains Ecological Landscape in the Mid-1800s
- Population Density, Cities, and Transportation of the Central Sand Plains Ecological Landscape

Note: Go to http://dnr.wi.gov/topic/landscapes/index.asp?mode=detail&Landscape=7 and click the "maps" tab.

Literature Cited

Allen, R.P. 1952. The Whooping Crane. National Audubon Society Resource Report 3, New York.

Anderson, C., L. Ayers, T. Bergeson, K. Grveles, K. Kirk, W.A. Smith, and S. Zolkowski. 2008. Biodiversity in selected natural communities related to climate change. Final Report to "Wisconsin Focus on Energy," Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Environmental Resources Program, Madison.

Andrae, M. 1986. History of Petenwell Flowage and Castle Rock projects. Web page. Available online at http://www.forciersguideservice.com/pages/the-history-of-the-petenwell-flowage.php. Accessed November 2007.

Australian Department of the Environment and Water Resources. 2007. Code of practice for Sphagnum moss harvesting. Web page. Available online at http://www.environment.gov.au/biodiversity/trade-use/wild-harvest/plants/sphagnum.html. Accessed August 2008.

Bordner, J.S., H.R. Aldrich, W.W. Morris, and J.H. Steenis. 1934. Land economic inventory of the State of Wisconsin: Juneau County. State of Wisconsin, Division of Land Economic Inventory, Madison.

Brockman, K.M., and R. A. Dow, editors. 1982. *Wildlife in early Wisconsin: a collection of works by A.W. Schorger*. Student Chapter of The Wildlife Society, Stevens Point, Wisconsin.

Brooks, C., and D. Hall. 1997. Gypsy moth silivicultural guidelines for Wisconsin. Wisconsin Department of Natural Resources, PUB-FR-123 97, Madison.

Cardille, J.A., S.J. Ventura, and M.G. Turner. 2001. Environmental and social factors influencing wildfires in the upper Midwest, United States. *Ecological Applications* 11(1):111–127.

Carr, C.F., editor. 1890. A list of the birds known to nest within the boundaries of Wisconsin, with a few notes thereon. *Wisconsin Naturalist* 1:2–6.

Clayton, L. 1987. Pleistocene geology of Adams County, Wisconsin. Wisconsin Geological and Natural History Survey, Information Circular 59, Madison.

Clayton, L. 1989. Geology of Juneau County, Wisconsin. Wisconsin Geological and Natural History Survey, Information Circular 66, Madison.

Clayton, L. 1991. Pleistocene geology of Wood County, Wisconsin. Wisconsin Geological and Natural History Survey, Information Circular 68, Madison.

Clayton, L., and J.W. Attig. 1989. Glacial Lake Wisconsin. The Geological Society of America, Memoir 173, Boulder, Colorado.

Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National hierarchical framework of ecological units. Pages 181–200 *in* M.S. Boyce and A. Haney, editors. *Ecosystem management: applications for sustainable forest and wildlife resources*. Yale University Press, New Haven, Connecticut.

Crum, H. 1988. *A focus on peatlands and peat mosses*. The University of Michigan Press, Ann Arbor.

Curtis, J.T. 1959. *The vegetation of Wisconsin: an ordination of plant communities*. University of Wisconsin Press, Madison.

Davis, M.G., compiler and editor. 1947. *A history of Wisconsin highway development, 1835–1945*. State Highway Commission of Wisconsin and the U.S. Public Roads Administration, Federal Works Agency, Madison, Wisconsin.

Dickmann, D.I., and D.T. Cleland. 2002. Fire return intervals and fire cycles for historic fire regimes in the Great Lakes Region: a synthesis of the literature. U.S. Forest Service, North Central Forest Experiment Station, Rhinelander, Wisconsin. Available online at http://www.ncrs.fs.fed.us/gla/natdist/purpose.htm. Accessed October 2007.

Dott, R.H., and J.W. Attig. 2004. *Roadside geology of Wisconsin*. Mountain Press Publishing Company, Missoula, Montana 346 pp.

Elling, A., E. and M.D. Knighton, 1984. Sphagnum moss recovery after harvest in a Minnesota bog. *Journal of Soil and Water Conservation* 39:209–211.

Esposito, K. 2000. Bringing in nature's bounty. *Wisconsin Natural Resources* April 2000.

Eswein, R.J. 1995. Logging dilemma in the Big Swamp: a late 1800s history of harvesting the last virgin pine forest of west central Wisconsin. Monroe County Historical Society, Sparta, Wisconsin.

Federal Emergency Management Agency (FEMA). 2007. Floodplain mapping. Web page. Available online at http://dnr.wi.gov/topic/FloodPlains/mapping.html. Accessed November 2007.

Finley, R. 1976. *Original vegetation of Wisconsin*. Map compiled from U.S. General Land Office notes. U.S. Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Fisher, C.E., editor. 1937. *The railroads of Wisconsin, 1827–1937*. The Railway and Locomotive Historical Society, Inc., Boston.

Forestry Commission Scotland. 2007. Scottish moss collection code. Harvesting guidelines website. Available online at http://www.forestharvest.org.uk/guidelines/mosscode_text.htm. Acessed August 2008.

Frissell, S.S. 1973. The importance of fire as a natural ecological factor in Itasca State Park, Minnesota. *Quaternary Research* 3(3):397–407.

Gerdol, R. 1995. The growth dynamics of *Sphagnum* based on field measurements in a temperate bog and on laboratory cultures. *Journal of Ecology* 83(3):431–437.

Gergel, S.E., M.D. Dixon, and M.G. Turner. 2002. Consequences of human-altered floods: levees, floods, and floodplain forests along the Wisconsin River. *Ecological Applications* 12(6):1755–1770.

Glaser, P.H. 1987. The ecology of patterned boreal peatlands of northern Minnesota: a community profile. U.S. Fish and Wildlife Service, Biological report; 85-7 (7.14), Washington, D.C.

Goc, M. 1990. The Wisconsin Dust Bowl. *Wisconsin Magazine of History* 73(3):163–201.

Gregg, L.E., and N.D. Niemuth. 2000. The history, status, and future of Sharp-Tailed Grouse in Wisconsin. *Passenger Pigeon* 62(2):158–174 pp.

Gundiach, H.F., R.R. Gilbertson, R.M. Johannes, and T.A. Meyer III. 1991. Soil survey of Juneau County, Wisconsin. U.S. Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin-Madison, Washington, D.C. Available online at http://soils.usda.gov/survey/printed_surveys/state.asp?state=Wisconsin&abbr=WI.

Harris, A., S.C. McMurray, P.W.C. Uhlig, J.K. Jeglum, R.F. Foster, and G.D. Racey. 1996. *Field guide to the wetland ecosystem classification for northwestern Ontario*. Ontario Ministry of Natural Resources, Northwest Science and Technology, Field Guide FG-01, Thunder Bay, Canada.

He, H.S., D.J. Mladenoff, T.A. Sickley, and G.G. Guntenspergen. 2000. GIS interpolations of witness tree records (1839-1866) for northern Wisconsin at multiple scales. *Journal of Biogeography* 27:1031–1042.

Ho-Chunk Nation. 2010. Ho-Chunk Nation tribal profile. Available online at http://witribes.wi.gov/section.asp?linkid=284&locid=57.

Hole, F. 1976. *Soils of Wisconsin*. University of Wisconsin Press, Madison.

Hole, F., and C. Germain. 1994. *The natural divisions of Wisconsin*. Map. Wisconsin Department of Natural Resources, Madison.

Hoy, P.R. 1885. Man's influence on the avifauna of southeastern Wisconsin. *Proceedings of the Natural History Society of Wisconsin* March 1885:4–9.

Inter-University Consortium for Political and Social Research (ICPSR). 2007. United States Historical Census Data Browser. Available online at http://fisher.lib.virginia.edu/census/.

Jakel, D.E. 1984. Soil survey of Adams County, Wisconsin. U.S. Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin-Madison, Washington, D.C. Available online at http://soils.usda.gov/survey/printed_surveys/state.asp?state=Wisconsin&abbr=WI.

Johnson, K.M., and C.L. Beale. 2002. Nonmetro recreation counties: their identification and rapid growth. *Rural America* 17(4):12–19.

Kirk, K. 1996. The Karner blue community: understanding and protecting associated rare species of the barrens. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Final report of U.S. Fish and Wildlife Service, Madison.

Kotar, J., and T.L. Burger. 1996. *A guide to forest communities and habitat types of central and southern Wisconsin*. University of Wisconsin-Madison,

Department of Forestry and Wildlife Ecology, Madison. 377 pp.

Kraft G.J., and D. J. Mechenich. 2010. Groundwater pumping effects on groundwater levels, lake levels, and stream flows in the Wisconsin Central Sands: a report to Wisconsin Department of Natural Resources in completion of Project NMI00000247. University of Wisconsin-Stevens Point, College of Natural Resources, Center for Watershed Science and Education, and University of Wisconsin Extension, Stevens Point. Available online at http://digital.library.wisc.edu/1711.dl/EcoNatRes.KraftGround. Accessed February 2010.

Kraft, G.J, D. Mechenich, and J. Haucke. 2012. Information support for groundwater management in the Wisconsin Central Sands, 2009-2011: a report to the Wisconsin Department of Natural Resources in completion of project NMA00000253. University of Wisconsin-Stevens Point, College of Natural Resources, Center for Watershed Science and Education, and University of Wisconsin Extension, Stevens Point. Available online at http://cnrfiles.uwsp.edu/kraft/kraft%20et%20al%202012%20central%20sands%20study/kraft%20et%20al%20central%20sands%20report%20FINAL.pdf.

Kumlien, L., and N. Hollister. 1903. The birds of Wisconsin. *Bulletin of the Wisconsin Natural History Society* 2:1–143.

Langton, J.E., and D.T. Simonson. 1998. Soil Survey of Jackson County, Wisconsin. U.S. Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Research Division of the College of Agricultural and Life Sciences, University of Wisconsin-Madison, Washington, D.C. Available online at http://soils.usda.gov/survey/printed_surveys/state.asp?state=Wisconsin&abbr=WI.

Leach, M., and T. Givnish. 1996. Ecological determinants of species loss in remnant prairies. *Science* 273:1555–1558.

Leach, M., and T. Givnish. 1999. Gradients in the composition, structure, and diversity of remnant oak savannas in Wisconsin. *Ecological Monographs* 69(3):353–374.

Macholl, J.A. 2007. Inventory of Wisconsin's springs. Wisconsin Geological and Natural History Survey, Open File Report 2007–03, Madison. 28 pp. Available online at http://wisconsingeologicalsurvey.org/wofrs.htm.

Manies, K.L., and D.J. Mladenoff. 2000. Testing methods to produce landscape-scale presettlement vegetation maps from the U.S. public land survey records. *Landscape Ecology* 15:741–754.

Martin, L. 1916. *The physical geography of Wisconsin*. Wisconsin Geological and Natural History Survey, Bulletin No. XXXVI, Madison.

Minnesota IMPLAN Group Inc. (MIG). 2009. IMPLAN data. Available online at https://implan.com/V4/Index.php. Accessed April 2009.

Mossman, M.J., E. Epstein, and R.M. Hoffman. 1991. Birds of pine and oak barrens. *Passenger Pigeon* 53:137–163.

National Oceanic and Atmospheric Administration (NOAA). 2005. *Total flood events: number of events, deaths, and injuries, 1996–2004.* Map. Available online at http://www.crh.noaa.gov/mkx/climate/severe/flood82-04.gif. Accessed November 2007.

National Oceanic and Atmospheric Administration (NOAA). 2007. *Lightning: number of events, deaths, and injuries, 1982–2003*. Map. Available online at http://www.crh.noaa.gov/mkx/climate/severe/lightning82-03.jpg. Accessed Nov 2007.

Nelson, E.C. 1978. Ecological factors influencing waterfowl production on three impoundments in central Wisconsin. Master's thesis, University of Wisconsin-Stevens Point, Stevens Point.

Nielsen, S.C., C. Kirschbaum, and A. Haney. 2003. Restoration of Midwest oak barrens: structural manipulation or process only? *Conservation Ecology* 7(2):10.

Ostergren, R., and T. Vale, editors. 1997. *Wisconsin land and life*. The University of Wisconsin Press, Madison.

Quintero, J. 2007. Regional economic development: an economic base study and shift-share analysis of Hays County, Texas. Texas State University, Applied Research Projects, Paper 259, San Marcos. Available online at http://ecommons.txstate.edu/arp/259/.

Portage County, Wisconsin, Government. 2008. Pesticide levels in Portage County groundwater. Web page. Available online at http://www.co.portage.wi.us/Groundwater/undrstnd/pestlvl.htm. Accessed March 2010.

Reich, P.B., M.D. Abrams, D.S. Ellsworth, E.L. Kruger, and T.J. Tabone. 1990. Fire affects ecophysiology and community dynamics of central Wisconsin oak forest regeneration. *Ecology* 71(6):2179–2190.

Roth, F. 1898. Forestry conditions and interests of Wisconsin. With a discussion by B.E. Fernow. U.S. Department of Agriculture, Division of Forestry, Bulletin No. 16, Washington, D.C. 76 pp.

Sample, D.W., and M.J. Mossman. 1997. Managing habitat for grassland birds: a guide for Wisconsin. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, PUB-SS-925-97, Madison. 154 pp.

Schorger, A.W. 1937. The great Wisconsin Passenger Pigeon nesting of 1871. *The Passenger Pigeon* 1(1):3–11. Available online at http://digital.library.wisc.edu/1711.dl/EcoNatRes.pp01n01.

Schorger, A.W. 1943. The Prairie Chicken and Sharp-tailed Grouse in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 35:1–59. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1943.

Schorger, A.W. 1946. The Passenger Pigeon in Wisconsin and problems with its history. Delivered at annual meeting of Wisconsin Society for Ornithology, Appleton, April 6, 1946. Reprinted in K.M. Brockman and R.A. Dow, Jr., editors. 1982. *Wildlife in early Wisconsin: a collection of works by A.W. Schorger.* Student Chapter of The Wildlife Society, Stevens Point, Wisconsin.

Schorger, A.W. 1964. The Trumpeter Swan as a breeding bird in Minnesota, Wisconsin, Illinois, and Indiana. *The Wilson Bulletin* 76(4):331–338.

Schreiber K. 1988. The impacts of commercial cranberry production on water resources. Wisconsin Department of Natural Resources, unpublished report, Madison. 37 pp.

Schreiber, K. 1993. Bio-monitoring below two commercial cranberry marshes in Jackson County, Wisconsin. Wisconsin Department of Natural Resources, Eau Claire. 10 pp.

Schulte, L.A., and D.J. Mladenoff. 2001. The original U.S. public land survey records: their use and limitations in reconstructing pre-European settlement vegetation. *Journal of Forestry* 99:5–10.

Simard, A.J., and R.N. Blank. 1982. Fire history of a Michigan jack pine forest. *Michigan Academician* 15(1):59–71.

Steele, Y. 2007. *Important Bird Areas of Wisconsin: critical sites for the conservation and management of Wisconsin's birds.* Wisconsin Department of Natural Resources, PUB-WM-475-2007, Madison. 240 pp.

Tasmanian Department of Primary Industries, Parks, Water, and Environment. 2006. Sphagnum moss: sustainable use and management. Web page. Available online at http://www.dpiw.tas.gov.au/inter.nsf/WebPages/BHAN-54A8CA?open. Accessed March 2010.

Taylor, T.A. 1934. 100 Years of pictorial and descriptive history of Wisconsin Rapids, Wisconsin. Web page. Available online http://www.scls.lib.wi.us/mcm/taylor/. Accessed November 2007.

Trick, J., and K. Grveles. 2010. Wisconsin Kirtland's Warbler 2010 Season Summary. U.S. Fish and Wildlife Service and Wisconsin Department of Natural Resources, Progress Report, Madison. Available online at http://www.fws.gov/midwest/greenbay/kiwa/2010/2010Summary.html.

The Wisconsin Cartographer's Guild. 1998. *Wisconsin's past and present: a historical atlas.* The University of Wisconsin Press, Madison. 123 pp.

U.S. Bureau of Economic Analysis (USBEA). 2006. Regional accounts data: local area personal income. U.S. Department of Commerce, Bureau of Economic Analysis website. Available online at http://www.bea.gov/regional/. Accessed April 2009.

U.S. Census Bureau (USCB). 2009. U.S. Census Bureau website. Available online at http://www.census.gov. Accessed April 2009.

U.S. Census Bureau (USCB). 2010. County business patterns. Available online at http://www.census.gov/econ/cbp/index.html. Accessed January 2010.

U.S. Census Bureau (USCB). 2012a. Census of population and housing: Wisconsin 2010 population and housing unit counts. U.S. Department of Commerce, U.S. Census Bureau, Washington, D.C. 217 pp. Available online at http://www.census.gov/prod/www/decennial.html.

U.S. Census Bureau (USCB). 2012b. 2010 census data. State and county quick facts. Web page. Available online at http://quickfacts.census.gov/qfd/states/55000.html. Accessed February 2012.

U.S. Census Bureau (USCB). 2013. North American Industry Classification

System. Web page. Available online at http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012a. 2004 county typology codes. Available online at http://www.ers.usda.gov, keywords "county typology codes." Last updated July 5, 2012.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012b. 2003 and 1993 urban influence codes for U.S. counties. Available online at http://www.ers.usda.gov, keywords "urban influence codes." Last updated July 5, 2012.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2004. 2002 census of agriculture: Wisconsin state and county data. Volume 1, Chapter 2: County level data. Table 1, county summary highlights: 2002. Available online at http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_County_Level/Wisconsin/.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2009. 2007 census of agriculture: Wisconsin state and county data. Volume 1, Chapter 2: County level data. Table 1: County summary highlights: 2007. Available online at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Wisconsin/. Accessed December 2010.

U.S. Department of Energy (USDE). 2013. Wisconsin 50-meter wind map. Web page. Available online at http://www.windpoweringamerica.gov/maps_template.asp?stateab=wi.

U.S. Fish and Wildlife Service (USFWS). 2004. Necedah National Wildlife Refuge Comprehensive Conservation Plan, Appendix A: Environmental Assessment. U.S. Fish and Wildlife Service, Region 3, Ft. Snelling, Minnesota.

U.S. Forest Service (USFS). 2004. Forest Inventory and Analysis, Mapmaker, Version 1.0. (*Note: USFS has discontinued the Forest Inventory and Analysis Mapmaker program. See the U.S. Forest Service's "Tools and Applications" web page, http://www.nrs.fs.fed.us/tools/software/.)*

U.S. Forest Service (USFS). 2007. Forest Inventory and Analysis, Timber Product Output Mapmaker, Version 1.0. Accessed October 2007. (*Note: USFS has discontinued the Timber Product Output Mapmaker program. See the U.S. Forest Service's "Tools and Applications" web page, http://www.nrs.fs.fed.us/tools/software/.)*

U.S. Forest Service (USFS). 2009. Forest Inventory and Analysis, Mapmaker, Version 4.0. (*Note: USFS has discontinued the Forest Inventory and Analysis Mapmaker program. See the U.S. Forest Service's "Tools and Applications" web page, http://www.nrs.fs.fed.us/tools/software/.)*

U.S. Forest Service (USFS). 2013. Forest health and economics. Web page. Available online at http://na.fs.fed.us/fhp/index.shtm. Accessed December 2013.

U.S. Geological Survey (USGS). 2009. Estimated use of water in the United States: county-level data for 2000. Web page. Available online at http://water.usgs.gov/watuse/data/2000/index.html. Accessed June 2009.

University of Wisconsin-Extension (UWEX). 2004. Adams County agriculture: value and economic impact. Brochure. Available online at http://www.uwex.edu/ces/ag/wisag/2004/documents/Adams.pdf. Accessed September 2010.

Whinam, J., and R. Buxton. 1997. Sphagnum peatlands of Australia: an assessment of harvesting sustainability. *Biological Conservation* 82(1):21–29.

Whitney, G.G. 1986. Relation of Michigan's presettlement pine forests to substrate and disturbance history. *Ecology* 67(6):1548–1559.

Whooping Crane Eastern Partnership (WCEP). 2013. Website. Available online at http://www.bringbackthecranes.org/. Accessed December 2013.

Wisconsin Commercial Ports Association (WCPA). 2010. Wisconsin ports. Website. Available online at http://www.wcpaports.org/ports. Accessed December 2010.

Wisconsin Department of Administration (DOA). 2000. Wisconsin roads 2000 TIGER line files (dataset). Wisconsin Department of Administration, Office of Land Information Services, Madison.

Wisconsin Department of Administration (DOA). 2006. Wisconsin energy statistics, 2006. Wisconsin Department of Administration, Division of Energy, Madison. Available online at http://www.doa.state.wi.us/, keyword "energy statistics."

Wisconsin Department of Natural Resources (DNR). 1993. WISCLAND land cover data. Available online at http://dnr.wi.gov/maps/gis/datalandcover.html#data. Accessed December 2009.

Wisconsin Department of Natural Resources (DNR). 1997. Trumpeter Swan fact sheet. Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources (DNR). 1999. Wisconsin Wolf Management Plan. Wisconsin Department of Natural Resources, PUBL-ER-099 99, Madison. Available online at http://dnr.wi.gov/, keywords "wolf management." Accessed February 2010.

Wisconsin Department of Natural Resources (DNR). 2002a. The state of the central Wisconsin River basin. Wisconsin Department of Natural Resources, PUBL WT 558 2002, Madison. Available online at http://dnr.wi.gov/water/basin/cwrb/CRWB_PRFINAL_6_18_02.pdf.

Wisconsin Department of Natural Resources (DNR). 2002b. The state of the lower Wisconsin River basin. Wisconsin Department of Natural Resources, PUBL WT-559-2001, Madison.

Wisconsin Department of Natural Resources (DNR). 2005a. Wisconsin DNR managed lands – "dissolved" version. Wisconsin Department of Natural Resources, Madison. See Wisconsin DNR managed lands web mapping application for current database, available at http://dnr.wi.gov/topic/Lands/PAL/.

Wisconsin Department of Natural Resources (DNR). 2005b. Wisconsin's strategy for wildlife species of greatest conservation need. Wisconsin Department of Natural Resources, Wisconsin Wildlife Action Plan, PUB-ER-641-2005, Madison. Available online at http://dnr.wi.gov/, keywords "wildlife action plan."

Wisconsin Department of Natural Resources (DNR). 2006a. *Old-growth and old forests handbook*. Wisconsin Department of Natural Resources, Handbook 2480.5, Madison. 74 pp.

Wisconsin Department of Natural Resources (DNR). 2006b. The 2005–2010 Wisconsin Statewide Comprehensive Outdoor Recreation Plan (SCORP). Wisconsin Department of Natural Resources, PR-026-2006, Madison. Available online at http://dnr.wi.gov, keyword "SCORP."

Wisconsin Department of Natural Resources (DNR). 2006c. *Wisconsin land legacy report: an inventory of places to meet conservation and recreation needs*. Wisconsin Department of Natural Resources, PUB-LF-040-2006, Madison. 247 pp. Available online at http://dnr.wi.gov, keywords "land legacy."

Wisconsin Department of Natural Resources (DNR). 2006d. Wisconsin Whooping Crane Management Plan. Wisconsin Department of Natural Resources, PUB-ER-650-06, Madison.

Wisconsin Department of Natural Resources (DNR). 2007. Wisconsin 2006 Water Quality Assessment Report to Congress. Wisconsin Department of Natural Resources, PUB WT 878 2007, Madison.

Wisconsin Department of Natural Resources (DNR). 2008. Managed Forest Law stumpage rates. These data are available by request from the Forest tax program, Wisconsin DNR, Madison.

Wisconsin Department of Natural Resources (DNR). 2009. Wisconsin Natural Heritage Inventory Working List. April 2009. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison. Current Working List available online at http://dnr.wi.gov/, keyword "NHI." Accessed March 11, 2010. *(Note: The Wisconsin Natural Heritage Working List is dynamic and updated periodically as new information is available. The April 2009 Working List was used for this publication. Those with questions regarding species or natural communities on the Working List should contact Julie Bleser, Natural Heritage Inventory Data Manager, Bureau of Endangered Resources, Wisconsin DNR at (608) 266-7308 or julie.bleser@wisconsin.gov).*

Wisconsin Department of Natural Resources (DNR). 2010a. Regional and property analysis – Black River State Forest. Wisconsin Department of Natural Resources, Division of Forestry. Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources (DNR). 2010b. *Silviculture and forest aesthetics handbook*. Chapter 24, Tree marking and retention guidelines. Handbook 2431.5, Wisconsin Department of Natural Resources, Madison. Available online at http://dnr.wi.gov, keyword "silviculture."

Wisconsin Department of Natural Resources (DNR). 2010c. Wisconsin Wet-

land Inventory. Web page. Available online at http://dnr.wi.gov/, keywords "wetland inventory." Accessed September 2010.

Wisconsin Department of Natural Resources (DNR). 2012a. Hydrography Geodatabase. Web page. Available online at http://dnr.wi.gov/maps/gis/datahydro.html.

Wisconsin Department of Natural Resources (DNR). 2012b. Outstanding and Exceptional Resource Waters. Web page. Available online at http://dnr.wi.gov, keywords "ORW/ERW."

Wisconsin Department of Natural Resources (DNR). 2012c. Wisconsin's impaired waters. Web page. Available online at http://dnr.wi.gov, keywords "impaired waters."

Wisconsin Department of Natural Resources (DNR). 2013a. Forest health. Web page. Available online at http://dnr.wi.gov, keywords "forest health."

Wisconsin Department of Natural Resources (DNR). 2013b. Invasive species. Web page. Available online at http://dnr.wi.gov/, keywords "invasive species."

Wisconsin Department of Natural Resources (DNR). 2013c. State Natural Areas Program. Web page. Available online at http://dnr.wi.gov/, keywords "state natural areas."

Wisconsin Department of Transportation (DOT). 1998. 1:100,000-scale Rails Chain Database. Wisconsin Department of Transportation, Bureau of Planning, Madison.

Wisconsin Department of Transportation (DOT). 2012. Wisconsin airport directory 2011–2012. Web page. Available online at http://www.dot.wisconsin.gov/travel/air/airportdirectory.htm.

Wisconsin Geological and Natural History Survey (WGNHS). 1914. Soil survey of Juneau County, Wisconsin. Bulletin No. 38D, Soil Series No. 8. Wisconsin Geological and Natural History Survey Madison.

Wisconsin Geological and Natural History Survey (WGNHS). 1924. Soil survey of Adams County, Wisconsin. Bulletin No. 61D, Soil Series No. 42. Wisconsin Geological and Natural History Survey Madison.

Wisconsin Geological and Natural History Survey (WGNHS). 1983. *Thickness of unconsolidated material in Wisconsin*. Map. Wisconsin Geological and Natural History Survey, Madison. Available online at http://wisconsingeologicalsurvey.org/uncon.htm.

Wisconsin Geological and Natural History Survey (WGNHS). 2006. Bedrock stratigraphic units in Wisconsin. Wisconsin Geological and Natural History Survey, Open-File Report 2006-06, Madison.

Wisconsin Geological and Natural History Survey (WGNHS) and Wisconsin Department of Natural Resources (DNR). 1989. *Groundwater contamination susceptibility in Wisconsin*. Map. Available online at http://www.uwex.edu/wgnhs/gwmap.htm. Accessed January 19, 2010.

Wisconsin Groundwater Coordinating Council (WGCC). 2009. Groundwater: Wisconsin's buried treasure–2009. Report to the Legislature. Groundwater Coordinating Council, Madison. *(Note: The current groundwater report to the legislature is available online at http://dnr.wi.gov, keywords "GCC report.")*

Wisconsin Land Type Associations Project Team. 2002. *Landtype Associations of Wisconsin*. Map. Wisconsin Department of Natural Resources, Madison.

Wisconsin State Cranberry Growers Association. 2008. Corps of Engineers finalizes new permitting process for Wisconsin cranberry marshes. Press release: December 16, 2008. Available online at http://www.wiscran.org/special/libfile_files/media/185.pdf. Accessed February 2010.

Wisconsin Wind Information Center (WWIC). 2013. Existing Wisconsin wind farms: commercial wind energy installations in Wisconsin 1998–2013. Web page. Available online at http://www.wiwindinfo.net/projects/overview.html.

Additional References

Bowe, S.A., D.W. Marcouiller, and M.D. LaBissoniere. 2004. Regional dependence and location of the wood products sector in the Northeastern United States: unique attributes of an export-based industry. *Wood and Fiber Science* 36(2):161–173.

Bowe, S.A., and D.W. Marcouiller. 2007. Natural resources and the tourism-Timber tradeoff: issues of regional dependency and economic diversity. *Forest Policy and Economics* 9: 653–670.

Cochrane, T.S., and H.H. Iltis. 2000. *Atlas of the Wisconsin prairie and savanna flora*. Wisconsin Department of Natural Resources, Technical Bulletin 191, Madison.

Epstein, E., C. Anderson, W. Smith, E. Judziewicz, and D. Feldkirchner. 2005. Biotic inventory and analysis of the Black River State Forest/Meadow Valley landscape. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUBL ER-805 2005, Madison.

Kennecott, R. 1855. Catalogue of animals observed in Cooke County, Illinois. *Transactions of Illinois State Agriculture Society* 1:577–595.

Klick, T.A., and C.W. Threinen. 1967. Surface water resources of Wood County. Wisconsin Department of Natural Resources, Madison.

Klick, T.A., and C.W. Threinen. 1968. Surface water resources of Jackson County. Wisconsin Department of Natural Resources, Madison.

Klick, T.A., and C.W. Threinen. 1969. Surface water resources of Juneau County. Wisconsin Department of Natural Resources, Madison.

Klick, T.A., and C.W. Threinen. 1969. Surface water resources of Monroe County. Wisconsin Department of Natural Resources, Madison.

Kotar, J., J. Kovach, and G. Brand. 1996. Analysis of the 1996 Wisconsin forest statistics by habitat type. U.S. Forest Service, North Central Research Station, St. Paul, Minnesota.

Kotar, J., J. Kovach, and T. Burger. 2002. *A guide to forest communities and habitat types of northern Wisconsin*. Second edition. University of Wisconsin-Madison, Department of Forestry and Wildlife Ecology, Madison.

Marcouiller, D.W., and J. Prey. 2005. The tourism supply linkage: recreational sites and their related natural amenities. *Journal of Regional Analysis and Policy* 35(1):29–39.

Marcouiller, D.W., I. Scott, and J. Prey. 2008. Outdoor recreation planning: a comprehensive approach to understanding use interaction. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 3(90):1–12.

Marcouiller, D.W., J. Prey, and I. Scott. 2009. The regional supply of outdoor recreation resources: demonstrating the use of location quotients as a management tool. *Journal of Parks and Recreation Administration* 27(4): 92–107.

Roe, L.A. 1990. *A history of Wisconsin mining*. Roeco, Madison.

Shaw, B., and Albertson, P.N. 1998. Little Plover River study. University of Wisconsin-Stevens Point, Final report, Pesticide research contract #95-03 to Wisconsin Department of Agriculture, Trade and Consumer Protection, Stevens Point.

Stier, J.C., K.K. Kim, and D.W. Marcouiller. 1999. Growing stock, forest productivity, and land ownership. *Canadian Journal of Forest Research* 29(6):1736–1742.

U.S. Department of Agriculture. 2009. Summary report: 2007 National Resources Inventory. Table: Surface area of nonfederal and federal land and water areas, by state and year. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C., and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa.

U.S. Department of Commerce, Bureau of Economic Analysis. 2012. Regional accounts data: local area personal income. Interactive data web page. Available online at http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=5#reqid=70&step=1&isuri=1.

U.S. Department of Labor, Bureau of Labor Statistics. 2012. Local area unemployment statistics data. Website. Available online at http://www.bls.gov/lau/.

U.S. Fish and Wildlife Service. 2004. Necedah National Wildlife Refuge Comprehensive Conservation Plan. U.S. Fish and Wildlife Service Washington, D.C. Available online at http://www.fws.gov/midwest/planning/Necedah/ccp/FinalCCP.pdf.

U.S. Fish and Wildlife Service. 2012. Necedah National Wildlife Refuge. Web page. Available online http://www.fws.gov/refuge/necedah/.

Village of Necedah, Wisconsin. 2007. Necedah, Wisconsin, historical overview. Web page. Available online at http://www.necedah.us/History.htm.

Wisconsin Department of Natural Resources. 1983. Master Plan for the Black River State Forest. Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources. 1999. Wisconsin's Northern State Forest assessments: regional ecology. Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources. 2000. Wisconsin statewide Karner blue butterfly Habitat Conservation Plan and Environmental Impact Statement. Wisconsin Department of Natural Resources, PUBL-SS-947-00, Madison.

Wisconsin Department of Natural Resources. 2001. The state of the Lower Chippewa River basin. Wisconsin Department of Natural Resources, PUBL WT-554 2001, Madison.

Wisconsin Department of Natural Resources. 2001. Wisconsin's Northern State Forest assessments: recreational supply and demand. Wisconsin Department of Natural Resources, PUB-FR-137 2001, Madison.

Wisconsin Department of Natural Resources. 2002. The state of the Black-Buffalo-Trempealeau basin. Wisconsin Department of Natural Resources, PUBL WT-556-2002, Madison.

Wisconsin Department of Natural Resources. 2003. Recreational Assessment of the Black River State Forest Region. Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources. 2004. Black River State Forest. Wisconsin Department of Natural Resources, PUB-FR-154-2004, Madison.

Wisconsin Department of Natural Resources. 2005. Biotic inventory and analysis of the Black River State Forest/Meadow Valley Landscape. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Natural Heritage Inventory Program, PUBL ER-805-2005, Madison.

Wisconsin Department of Natural Resources. 2007. Fish, Wildlife, and Habitat Management Plan for Wisconsin, 2007–2013 (June 2007). Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources. 2008. Wisconsin Wildlife Action Plan Implementation Report. Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources. 2009. *Wisconsin lakes.* Wisconsin Department of Natural Resources, PUB-FM-800, Madison.

Wisconsin Department of Natural Resources. 2010. Biological inventory data for Black River State Forest Master Plan. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison. Unpublished.

Wisconsin Department of Natural Resources. 2012. Wisconsin lakes partnership: county list of lakes. Available online at http://dnr.wi.gov/lakes/lakespartnership/.

Wisconsin Department of Workforce Development. 2011. County workforce profiles. Wisconsin Department of Workforce Development, Office of Economic Advisors, OEA-10619-P. Website. Available online at http://dwd.wisconsin.gov/oea/.

Wisconsin Groundwater Advisory Committee. 2006. 2006 Report to the Legislature on groundwater management areas. Wisconsin Department of Natural Resources, Bureau of Drinking Water and Groundwater, Madison.

Yenne, B. 1986. *The encyclopedia of North American Indian tribes*. Arch Cape Press, Greenwich, Connecticut.

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